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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. NOVEMBER 14, 1884. No. 1.

EDWIN DUNKIN, F.R.S., President, in the Chair.

Pietro Baracchi, the Observatory, Melbourne, Australia, was duly elected a Fellow of the Society.

Prof. Th. Bredichin, Observatory, Moscow;
M. Magnus Nyrén, Observatory, Pulkowa; and
Prof. Edward S. Holden, Washburn Observatory, Madison, Wisconsin,

were duly elected Associates of the Society.

Extract from a Letter of M. Gogou to Prof. J. C. Adams on the Numerical Value of the Coefficient of Neison's Long Inequality in the Moon's Motion due to the Action of Mars.

(*Communicated by Prof. Adams.*)

En relisant la Note que M. Neison a publiée dans le vol. 42 No. 5 des *Monthly Notices* (Mars 1882, p. 266–268), j'ai vu qu'il s'appésantissait sur le fait que mes résultats ne s'étendent pas au-delà de la 3[e] puissance et produits des excentricités de *Mars* et de la Terre. En parlant des termes dépendant des 5[ièmes] et 7[ièmes] puissances et produits des excentricités, il s'exprime comme il suit: "M. Gogou has entirely neglected these terms, *whereas in my investigation I retained them*" (p. 268). Or, comme j'ai déjà remarqué dans mon Mémoire que je vous ai envoyé dernièrement, il n'y a que dans les quantités qui multiplient les coefficients $[B_{\frac{1}{2}}]^{24}_{21}$, $[B_{\frac{1}{2}}]^{23}_{20}$ qu'il a conservé les termes en e''^{2}, termes que moi je n'ai pas conservés dans mon calcul, pour les raisons que j'ai développées dans mon Mémoire.

En effet, M. Neison avait posé

$$R''' = \sigma m^2 a^4 \frac{a}{a'} \cdot \frac{r^3}{n^4}\left\{\frac{15}{16}[(1+2\alpha^2+3e'''^2)[B_{\frac{7}{2}}]^{24}_{21} - (2+\alpha^2+3e'''^2)\alpha\,[B_{\frac{7}{2}}]^{23}_{20} + \ldots\right\}$$

tandis que moi j'ai posé

$$R''' = \sigma m^2 a^4 \frac{a}{a''} \cdot \frac{r^3}{a^4}\left\{\frac{15}{16}[(1+2\alpha^2)[B_{\frac{7}{2}}]^{24}_{21} - (2+\alpha^2)\alpha\,[B_{\frac{7}{2}}]^{23}_{20} + \ldots\right\}$$

S'il s'agissait de tenir compte de deux termes en e'''^2 compris dans le développement donné par M. Neison, on devrait ajouter à la valeur de la partie (R) de la fonction perturbatrice R''', donnée dans mon Mémoire, une partie (R_2) telle qu'on ait

$$\begin{array}{lllll}
(R_2) = \frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{24}e''^3) - 3\alpha e'''^2(B_{\frac{7}{2}}^{23}e''^3)]\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] & & & \\
+\frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{23}e''e'''^2) - 3\alpha e'''^2(B_{\frac{7}{2}}^{22}e''e'''^2)]\cos\,[& ,, & ,, & +\varpi''+2\varpi'''] \\
+\frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{22}e''^2e''') - 3\alpha e'''^2(B_{\frac{7}{2}}^{21}e''^2e''')]\cos\,[& ,, & ,, & +2\varpi''+\varpi'''] \\
+\frac{15}{16}\alpha[3e'''^2(B_{\frac{7}{2}}^{21}e''^3) - 3\alpha e''^2(B_{\frac{7}{2}}^{20}e''^3)]\cos[& ,, & ,, & +3\varpi''],
\end{array}$$

laquelle, après la mise en nombres, se réduit à

$$\begin{array}{lllll}
(R_2) = & -12{,}133e'''^5\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] & & & \\
& +71{,}605e''e'''^4\cos\,[& ,, & ,, & +\varpi''+2\omega'''] \\
& -146{,}246e''^2e'''^3\cos\,[& ,, & ,, & +2\varpi''+\varpi'''] \\
& +102{,}315e''^3e'''^2\cos\,[& ,, & ,, & +3\varpi''].
\end{array}$$

ou encore, en remplaçant e'''^2 par sa valeur $=(0{\cdot}0932616)^2$,

$$\begin{array}{ll}
(R_2) = & -0{,}1055e'''^3\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] \\
& +0{,}6228e''e'''^2\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+\varpi''+2\varpi''' \\
& -1{,}2720e''^2e'''\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+2\varpi''+\varpi'''] \\
& +0{,}8899e''^3\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi''].
\end{array}$$

En ajoutant cette valeur à celle donnée dans mon Mémoire pour (R), on trouve

$$\begin{array}{lllll}
(R)+(R_2) = & +0{,}01e'''^3\cos\,[(n-24n''+20n''')t+\epsilon-24\epsilon''+20\epsilon'''+3\varpi'''] & & & \\
& -0{,}01e''e'''^2\cos\,[& ,, & ,, & +\varpi''+2\varpi'''] \\
& -0{,}21e''^2e'''\cos\,[& ,, & ,, & +2\varpi''+\varpi'''] \\
& +0{,}35e''^3\cos\,[& ,, & ,, & +3\varpi''].
\end{array}$$

Ainsi donc, si l'on se bornait à rectifier seulement les erreurs dont est entaché le développement donné par M. Neison pour la fonction perturbatrice qui provient de l'action directe de *Mars*

sur la Lune, et si l'on s'arrêtait, dans ce développement, aux seuls termes conservés par lui, on trouverait

$$
\begin{aligned}
\mathrm{R}''' = m''' \frac{a^2}{a''a'''^3} \Big\{ & 0{,}01e'''^3 \cos\left[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''\right] \\
& - 0{,}01e''e'''^2 \cos\left[(\quad \text{,,} \quad\quad \text{,,} \quad + \varpi'' + 2\varpi'''\right] \\
& - 0{,}21e''^2e''' \cos\left[\quad \text{,,} \quad\quad \text{,,} \quad + 2\varpi'' + \varpi'''\right] \\
& + 0{,}35e''^3 \cos\left[\quad \text{,,} \quad\quad \text{,,} \quad + 3\varpi''\right] \Big\}.
\end{aligned}
$$

Substituant cette valeur dans l'équation qui donne la variation $\delta(\varpi + l)$ de la longitude moyenne de la Lune, on trouve pour l'inégalité qui nous occupe l'expression suivante

$$
\begin{aligned}
\delta(\varpi + l) = & -3m''' \frac{a}{a''a'''^3} \cdot \frac{1}{(n - 24n'' + 20n''')^2} \\
& \times \{0{,}01e'''^3 \sin\left[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''\right] \\
& \quad - 0{,}01e''e'''^2 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + \varpi'' + 2\varpi'''\right] \\
& \quad - 0{,}21e''^2e''' \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 2\varpi'' + \varpi'''\right] \\
& \quad + 0{,}35e''^3 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 3\varpi''\right]\}.
\end{aligned}
$$

Si l'on désigne par σ le rapport de la masse de *Mars* à celle du Soleil, on aura

$$m''' = \sigma n''^2 a''^3 = \sigma n''^2 a^3 a'''^3,$$

et, par suite,

$$
\begin{aligned}
\delta(\varpi + l) = & -3\sigma \frac{n''^2}{(n - 24n'' + 20n''')^2} a^3 \frac{a}{a''} \\
& \times \{0{,}01e'''^3 \sin\left[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''\right] \\
& \quad - 0{,}01e''e'''^2 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + \varpi'' + 2\varpi'''\right] \\
& \quad - 0{,}21e''^2e''' \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 2\varpi'' + \varpi'''\right] \\
& \quad + 0{,}35e''^3 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 3\varpi'')\right\}.
\end{aligned}
$$

En adoptant pour les lettres qui entrent dans cette formule les mêmes valeurs qu'a adoptés M. Neison, savoir

$$
\begin{array}{lll}
\sigma = \dfrac{1}{3{,}000{,}000} & \dfrac{a}{a''} = 0{,}0025856 & \log a = \bar{1}{,}8171030 \\
n = 17{,}325{,}594'',0 & n'' = 1{,}295{,}977'',38 & n''' = 689050{,}98 \\
& e'' = 0{,}01677106 \qquad e''' = 0{,}0932616 &
\end{array}
$$

j'ai trouvé

$$
\begin{aligned}
\delta(\varpi + l) = & -0'',000206 \sin\left[(n - 24n'' + 20n''')t + \epsilon - 24\epsilon'' + 20\epsilon''' + 3\varpi'''\right] \\
& + 0'',000037 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + \varpi'' + 2\varpi'''\right] \\
& + 0'',000140 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 2\varpi'' + \varpi'''\right] \\
& - 0'',000042 \sin\left[\quad \text{,,} \quad\quad \text{,,} \quad + 3\varpi''\right],
\end{aligned}
$$

B 2

résultat tout-à-fait différent de celui publié par M. Neison dans les *Monthly Notices* du Novembre 1877.

Dans la Note que M. Neison a publiée dans les *Monthly Notices* du Mars 1882, il reconnaît d'ailleurs que la valeur trouvée par lui pour le coefficient de l'inégalité en question était beaucoup trop fort et que sa vraie valeur *doit être seulement d'une petite fraction de seconde*, au lieu de plusieurs secondes :—

Voici du reste textuellement le passage en question de la Note ci-dessus citée :

"... the value found for the coefficient of this new term of long period was far too large. This fact I mentioned in my paper on Hansen's Terms of Long Period (*Monthly Notices*, March 1878, p. 269).

"Since then I have more accurately computed the value of this part of this term, and find its true value to be only a small fraction of a second, instead of several seconds."

J'ai cru nécessaire de rappeler ce passage de la Note de M. Neison, car je crois qu'à la suite d'une telle affirmation il n'y aurait plus lieu de se demander d'où provient l'énorme différence entre mon résultat et celui publié par M. Neison.

Dans une Note publiée dans le vol. 43 des *Monthly Notices*, p. 216, après constatation que mon résultat s'élève à peine à 0″·00034, il y a en effet ce passage : "Il est difficile de voir d'où provient l'énorme différence entre ce résultat [le mien] et celui de M. Neison." Cette différence, d'après la déclaration même de M. Neison, tient, comme on le voit, à une erreur commise par lui dans les calculs.

Campulungu, Roumanie :
Le 9 *Août*, 1884.

The Proper Motions of the 460 *Stars given in the R.A.S. Memoirs*, vol. xxxiii., *when the Places of Auwers's Re-reduction of Bradley's Observations are adopted instead of Bessel's, with Notes on the Proper Motion of μ Piscium.* By E. J. Stone, M.A., F.R.S.

In the formation of my Cape Catalogue of 12,441, 1880, I adopted the usually accepted proper motions of the Bradley stars without any special examination.

For *μ Piscium* the values adopted from Main, *R.A.S. Memoirs*, vol. xix. p. 163, are R.A. $+0^s{\cdot}019$ and N.P.D. $+0''{\cdot}18$.

Recently I have thought it desirable to re-examine some of these adopted values by comparisons between the Southern Catalogues. By comparing the Cape Catalogue, 1840, with that for 1880, I find for *μ Piscium* the proper motions

R.A. $+0^s{\cdot}021$. N.P.D. $-0''{\cdot}01$.

The proper motion in R.A. agrees closely with the adopted value, but that in N.P.D. is utterly discordant.

A comparison between recent Northern observations and the Cape observations confirms the smallness of the proper motion in N.P.D. It appeared, therefore, that there must be something wrong in the declination given in Bessel's *Fundamenta*. A comparison between Auwers's re-reduction of Bradley's observations and the Cape Catalogue, 1880, gives

R.A. + $0^s{\cdot}019$ and N.P.D. + $0''{\cdot}02$.

The declinations for 1755 given by Bessel and Auwers differ $13''{\cdot}17$.

It would appear, therefore, that the usually adopted value of the proper motion in R.A. + $0^s{\cdot}019$ is sensibly correct; whilst the proper motion in N.P.D., instead of being equal to + $0''{\cdot}18$, is very small indeed.

I have also examined the proper motions of *σ Ceti*, Bradley 356. In this case the proper motions given by the Cape Catalogues, 1840 and 1880, are

R.A. − $0^s{\cdot}014$, N.P.D. + $0''{\cdot}11$.

A comparison between Auwers's Bradley and the Cape, 1880, however, only gives

R.A. − $0^s{\cdot}007$, N.P.D. + $0''{\cdot}11$.

The difference $0^s{\cdot}007$ in R.A. is, I believe, larger than can be due to errors in the places of the 1840 and 1880 Catalogues. The proper motion in R.A. is more probably − $0^s{\cdot}012$ than − $0^s{\cdot}007$.

In the case of r^5 *Eridani*, Bradley 495, a comparison between the Cape Catalogues 1840 and 1880 gives the proper motions

R.A. + $0^s{\cdot}004$, N.P.D. + $0''{\cdot}03$.

The values usually adopted have been

R.A. − $0^s{\cdot}003$, N.P.D. + $0''{\cdot}03$.

The discordance in sign in the proper motion in R.A. disappears if we adopt Auwers's re-reduction, we thus find that the Cape, 1880, and Bradley then give

R.A. + $0^s{\cdot}002$, N.P.D. + $0''{\cdot}03$.

As a general rule, however, the agreement between the determinations of the proper motions from the Greenwich observations and Bessel's Bradley, and those from the Cape observations, is exceedingly close.

I have added the proper motions of the 460 stars which I deduced some years ago from a comparison between the Greenwich Catalogue, 1860, and Bessel's *Fundamenta*, where Auwers's places are used instead of Bessel's for Bradley's results.

Peters's constants have been adopted as before.

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
3220	22 Andromedæ	+0·002	+0·01
3222	6 Ceti	−0·007	+0·26
6	Bradley 6	—	+0·03
36	11 Ceti	+0·012	+0·05
40	14 Cassiopeiæ λ	+0·003	+0·02
46	16 Cassiopeiæ	−0·002	+0·01
67	20 Cassiopeiæ π	−0·002	+0·02
71	17 Ceti φ′	−0·002	+0·11
72	23 Cassiopeiæ	—	+0·03
80	60 Piscium	0·000	0·00
83	25 Cassiopeiæ ν	+0·003	0·00
104	38 Andromedæ η	−0·002	+0·04
92	2 Ursæ Minoris	+0·068	+0·01
129	41 Andromedæ	+0·014	+0·07
150	84 Piscium χ	0·000	−0·01
177	46 Andromedæ ξ	+0·003	−0·01
185	93 Piscium ρ	−0·005	−0·03
189	94 Piscium	+0·002	+0·03
211	101 Piscium	−0·001	0·00
217	Bradley 217	+0·008	—
223	105 Piscium	+0·004	0·00
229	107 Piscium	−0·021	+0·66
231	109 Piscium	−0·005	+0·06
262	8 Arietis ι	+0·001	+0·01
271	112 Piscium	+0·014	+0·25
273	59 Ceti υ	+0·007	+0·02
296	15 Arietis	+0·006	+0·03
299	6 Persei	+0·036	+0·20
317	8 Trianguli δ	+0·091	+0·23
329	68 Ceti o	−0·002	+0·22
348	Bradley 348	−0·004	−0·01
363	79 Ceti	−0·012	+0·43
364	31 Arietis	+0·018	+0·07
375	83 Ceti ε	+0·006	+0·25
366	Bradley 366	+0·001	+0·04
381	Bradley 381	−0·001	+0·03
390	1 Eridani τ^1	+0·022	−0·05
393	40 Arietis	+0·003	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
394	16 Persei	+0·017	+0·06
404	2 Eridani τ^2	−0·006	+0·02
423	5 Eridani	0·000	0·00
429	25 Persei ρ	+0·011	+0·10
435	10 Eridani ρ^3	+0·004	−0·01
431	Bradley 431	—	+0·07
448	Bradley 448		+0·02
461	95 Ceti	+0·016	+0·06
468	97 Ceti κ^2	+0·002	+0·03
478	34 Persei	+0·001	+0·07
471	Bradley 471	—	+0·06
487	17 Eridani	0·000	0·00
489	6 Tauri t	+0·002	+0·04
507	14 Tauri	+0·008	+0·04
518	25 Eridani	+0·002	−0·02
529	30 Tauri e	+0·001	+0·02
530	27 Eridani τ^6	−0·013	+0·54
536	Bradley 536	—	+0·02
540	32 Eridani	+0·003	0·00
541	33 Tauri	+0·005	—
553	38 Tauri ν	0·000	+0·01
558	41 Tauri	+0·002	+0·05
562	43 Tauri ω^1	+0·007	+0·03
570	46 Tauri	−0·002	−0·02
576	51 Tauri	+0·007	+0·03
582	52 Tauri ϕ	−0·001	+0·05
588	59 Tauri χ^1	+0·001	+0·02
599	65 Tauri κ^1	+0·005	+0·06
606	72 Tauri υ^2	0·000	0·00
620	81 Tauri	+0·008	—
618	57 Persei m	+0·001	+0·01
624	45 Eridani	0·000	+0·01
631	46 Eridani	0·000	+0·01
636	50 Eridani υ^4	−0·010	+0·28
650	Bradley 650	+0·007	+0·12
657	57 Eridani μ	0·000	0·00
675	5 Orionis	+0·001	+0·01
680	8 Orionis	0·000	0·00

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
677	3 Aurigæ ι	0·000	0·00
686	Bradley 686	0·000	. .
695	10 Orionis π^6	0·000	−0·01
697	63 Eridani	+0·001	+0·12
701	65 Eridani ψ	−0·002	−0·02
698	102 Tauri ι	+0·004	+0·05
713	2 Leporis ε	+0·002	+0·08
706	103 Tauri	0·000	. .
712	66 Eridani	0·000	+0·02
727	3 Leporis ι	0·000	0·00
725	17 Orionis ρ	0·000	0·00
765	28 Orionis η	−0·001	−0·01
758	24 Aurigæ φ	−0·001	+0·04
767	115 Tauri	0·000	0·00
790	121 Tauri	+0·001	+0·02
792	37 Orionis ϕ^1	−0·001	+0·01
843	14 Leporis ζ	−0·001	−0·01
858	15 Leporis δ	+0·017	+0·66
869	59 Orionis	+0·002	+0·01
878	64 Orionis χ^2	—	+0·02
885	66 Orionis	−0·002	+0·01
892	18 Leporis θ	−0·001	−0·02
902	2 Lyncis	+0·001	−0·03
916	73 Orionis k^1	0·000	0·00
920	5 Monocerotis	−0·001	-
928	7 Monocerotis	0·000	−0·01
945	9 Monocerotis	−0·001	−0·01
953	19 Geminorum	−0·001	0·00
957	12 Monocerotis	−0·004	−0·01
978	7 Canis Majoris ν^2	+0·004	+0·05
970	54 Aurigæ	−0·001	+0·02
981	15 Monocerotis	+0·001	0·00
986	28 Geminorum	−0·001	+0·01
984	57 Aurigæ	−0·003	+0·01
990	32 Geminorum	−0·001	−0·03
995	18 Monocerotis	—	+0·01
997	33 Geminorum	−0·002	−0·09
1004	36 Geminorum d	0·000	+0·04

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1007	37 Geminorum	−0·004	−0·02
1009	38 Geminorum *e*	+0·004	+0·07
1030	45 Geminorum	−0·002	+0·09
1041	20 Monocerotis	+0·006	−0·22
1038	48 Geminorum	−0·003	+0·03
1047	22 Monocerotis	−0·001	−0·03
1044	Piazzi vii.-11	—	−0·03
1050	53 Geminorum	−0·002	0·00
1055	24 Monocerotis	−0·001	−0·01
1059	27 Canis Majoris	−0·001	−0·05
1080	64 Geminorum b^1	−0·003	+0·05
1082	65 Geminorum b^2	−0·001	+0·01
1110	26 Monocerotis γ	−0·007	+0·02
1134	9 Puppis	−0·006	+0·34
1139	14 Canis Minoris	−0·012	−0·09
1140	2 Cancri ω^1	−0·001	−0·02
1153	Bradley 1153	−0·002	−0·13
1161	10 Cancri μ^2	+0·002	+0·05
1174	16 Puppis	0·000	−0·01
1179	20 Puppis	−0·001	+0·01
1181	18 Cancri χ	−0·001	+0·37
1197	Piazzi viii.-69	−0·004	−0·02
1195	2 Ursæ Majoris A	−0·009	+0·07
1213	36 Cancri c^1	−0·004	+0·01
1211	Piazzi viii.-110	−0·002	+0·01
1221	5 Hydræ σ	−0·004	0·00
1232	45 Cancri A^1	−0·001	−0·02
1235	7 Hydræ η	−0·002	−0·01
1239	48 Cancri ι	−0·001	+0·03
1248	13 Hydræ ρ	−0·002	+0·02
1254	55 Cancri ρ^2	−0·038	+0·23
1284	18 Hydræ ω	−0·001	−0·01
1280	15 Ursæ Majoris *f*	−0·013	+ ·
1279	14 Ursæ Majoris τ	+0·015	+0·07
1286	75 Cancri	−0·009	+0·37
1298	81 Cancri π^1	−0·038	−0·27
1299	Bradley 1299	0·000	+0·02
1300	Bradley 1300	−0·012	−0·05

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1303	22 Hydræ θ	+0·009	+0·30
1304	82 Cancri π^2	−0·002	−0·03
1307	23 Hydræ	−0·001	−0·02
1318	Bradley 1318	−0·010	−0·01
1320	1 Leonis κ	−0·002	+0·03
1327	29 Hydræ	−0·003	0·00
1328	2 Leonis ω	+0·003	−0·02
1337	9 Leonis Minoris	+0·002	+0·05
1340	10 Leonis Minoris	+0·001	0·00
1343	11 Leonis Minoris	−0·059	+0·25
1344	33 Hydræ	0·000	+0·03
1346	42 Lyncis	−0·001	−0·02
1349	10 Leonis	−0·005	−0·02
1356	35 Hydræ ι	+0·002	+0·06
1362	38 Hydræ κ	−0·001	−0·02
1372	19 Leonis	−0·006	−0·04
1373	Bradley 1373	−0·002	—
1380	4 Sextantis	−0·009	+0·02
1388	39 Hydræ υ^1	−0·001	+0·01
1386	7 Sextantis	−0·013	−0·14
1394	26 Leonis	−0·004	0·00
1397	20 Leonis Minoris	−0·040	+0·43
1407	15 Sextantis	--	−0·03
1409	16 Sextantis	−0·001	−0·01
1412	41 Hydræ λ	−0·014	+0·06
1425	36 Leonis ζ	+0·001	−0·02
1435	23 Sextantis	−0·001	−0·02
1429	Bradley 1429	—	+0·01
1444	29 Leonis Minoris	−0·009	+0·06
1445	30 Leonis Minoris	−0·006	+0·05
1439	Bradley 1439	—	−0·01
1459	30 Sextantis	−0·002	+0·01
1463	46 Leonis i	−0·003	−0·03
1465	34 Leonis Minoris	−0·005	−0·01
1458	Bradley 1458	+0·012	0·00
1475	37 Leonis Minoris	0·000	−0·04
1479	Hydræ ϕ^2	−0·009	−0·05
1490	42 Leonis Minoris	−0·003	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
1509	46 Leonis Minoris	+0·006	+0·25
1514	Bradley 1514	—	+0·03
1515	54 Leonis (1st star)	−0·006	−0·02
1517	55 Leonis	+0·006	−0·02
1522	47 Ursæ Majoris	−0·027	—
1530	61 Leonis p^1	+0·001	0·00
1529	60 Leonis *b*	−0·002	−0·05
1533	62 Leonis p^2	−0·006	−0·02
1536	9 Crateris	−0·016	+0·02
1538	Bradley 1538	+0·001	+0·02
1544	10 Crateris	−0·006	−0·03
1549	72 Leonis	−0·003	−0·01
1563	14 Crateris ε	−0·004	−0·05
1565	81 Leonis	—	0·00
1573	85 Leonis	−0·003	+0·03
1574	58 Ursæ Majoris	−0·005	−0·08
1577	88 Leonis	−0·024	+0·18
1582	89 Leonis	−0·012	+0·08
1581	2 Draconis	+0·014	+0·11
1590	1 Virginis ω	−0·001	+0·01
1593	61 Ursæ Majoris	−0·001	+0·39
1595	3 Draconis	−0·005	−0·03
1620	1 Comæ	−0·004	+0·01
1624	1 Corvi α	+0·005	+0·04
1630	4 Comæ	−0·003	+0·03
1639	6 Comæ	−0·006	0·00
1641	7 Comæ	−0·004	−0·01
1645	8 Comæ	−0·003	0·00
1650	Bradley 1650	—	−0·01
1654	11 Comæ	−0·009	−0·09
1658	12 Comæ	−0·001	−0·01
1661	13 Comæ	−0·001	+0·01
1665	14 Comæ	−0·002	+0·01
1666	15 Comæ	−0·007	+0·08
1667	16 Comæ	−0·001	0·00
1680	4 Draconis	—	+0·07
1681	8 Corvi η	−0·032	+0·05
1690	25 Virginis *f*	−0·003	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
1694	26 Virginis χ	−0·006	+0·02
1700	28 Virginis	0·000	+0·03
1701	30 Virginis ρ	+0·004	+0·08
1703	76 Ursæ Majoris	—	+0·03
1706	33 Virginis	+0·019	+0·45
1710	36 Virginis	+0·002	+0·01
1712	11 Canum Venaticorum	—	0·00
1727	8 Draconis	—	+0·05
1728	36 Comæ	−0·003	−0·05
1729	44 Virginis *k*	−0·003	−0·02
1732	46 Virginis	−0·003	−0·07
1733	37 Comæ	−0·002	0·00
1738	48 Virginis	−0·004	0·00
1740	39 Comæ	−0·006	+0·05
1744	45 Hydræ ψ	−0·004	+0·04
1746	50 Virginis	0·000	+0·01
1757	56 Virginis	−0·003	+0·04
1760	59 Virginis *e*	−0·023	−0·20
1761	58 Virginis	−0·007	−0·03
1762	60 Virginis σ	−0·003	−0·03
1767	21 Canum Venaticorum	−0·004	0·00
1766	62 Virginis	−0·010	−0·01
1772	65 Virginis	−0·004	−0·01
1773	66 Virginis	+0·010	+0·02
1775	68 Virginis *i*	−0·011	+0·02
1780	70 Virginis	−0·020	+0·57
1782	72 Virginis l^1	+0·002	−0·04
1783	73 Virginis	−0·008	+0·01
1786	76 Virginis *h*	−0·005	+0·02
1790	80 Virginis	0·000	−0·10
1793	81 Virginis	−0·002	—
1801	83 Virginis	+0·001	0·00
1804	85 Virginis	−0·006	+0·03
1806	87 Virginis	+0·001	+0·03
1826	9 Boötis	+0·001	+0·05
1858	103 Virginis	−0·006	0·00
1862	52 Hydræ	−0·003	+0·05
1865	105 Virginis φ	−0·009	−0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
1868	24 Boötis *g*	−0·032	+0·07
1877	31 Boötis	+0·001	+0·02
1883	34 Boötis	−0·001	0·00
1888	35 Boötis	−0·005	+0·05
1895	Bradley 1895	−0·007	—
1896	10 Libræ	−0·005	−0·01
1906	6 Ursæ Minoris	—	−0·02
1899	12 Libræ	−0·001	+0·04
1914	40 Boötis	—	−0·05
1915	110 Virginis	−0·004	−0·02
1920	22 Libræ ν^2	−0·008	+0·01
1924	45 Boötis	+0·012	+0·19
1928	25 Libræ	−0·005	+0·03
1935	48 Boötis χ	−0·026	−0·03
1965	52 Boötis ν^1	+0·001	+0·01
1967	53 Boötis ν^2	−0·003	+0·01
1968	4 Coronæ θ	−0·005	—
1986	21 Serpentis ι	−0·006	+0·03
1991	8 Coronæ γ	−0·008	+0·04
1994	9 Coronæ π	—	0·00
2010	10 Coronæ δ	−0·009	+0·07
2013	38 Serpentis ρ	−0·004	−0·02
2018	11 Coronæ κ	−0·002	+0·36
2021	1 Herculis χ	+0·037	−0·62
2037	15 Coronæ ρ	—	+0·78
2038	44 Serpentis π	0·000	−0·04
2058	16 Coronæ τ	−0·006	−0·33
2061	11 Herculis ϕ	—	−0·03
2081	50 Serpentis σ	+0·010	−0·04
2087	19 Coronæ ξ	—	−0·12
2083	5 Ophiuchi ρ	−0·003	+0·01
2089	23 Herculis	—	+0·02
2090	24 Herculis ω	—	+0·03
2093	25 Herculis	0·000	+0·01
2104	14 Draconis η	—	−0·04
2105	29 Herculis *h*	−0·014	+0·07
2108	12 Ophiuchi	+0·026	+0·30
2116	36 Herculis m^1	−0·001	−0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
2117	37 Herculis m^2	−0·002	+0·01
2125	39 Herculis	−0·001	+0·04
2130	41 Herculis	−0·017	—
2131	43 Herculis *i*	0·000	−0·04
2139	47 Herculis *k*	+0·002	−0·01
2145	50 Herculis	−0·004	−0·01
2153	Bradley 2153	−0·002	—
2155	26 Ophiuchi	−0·003	+0·08
2167	60 Herculis	+0·004	−0·01
2178	37 Ophiuchi	0·000	+0·03
2184	41 Ophiuchi	−0·004	+0·06
2195	69 Herculis *e*	−0·002	−0·08
2188	Bradley 2188	−0·005	+0·07
2192	43 Ophiuchi	0·000	+0·03
2220	57 Ophiuchi μ	−0·002	+0·01
2225	56 Serpentis o	−0·005	+0·02
2240	29 Draconis	—	−0·05
2230	3 Sagittarii	−0·002	+0·02
2239	87 Herculis	0·000	+0·03
2254	57 Serpentis ζ	+0·009	+0·04
2265	69 Ophiuchi τ	+0·002	+0·01
2269	96 Herculis	−0·001	+0·01
2271	70 Ophiuchi	+0·016	+1·10
2337	44 Draconis χ	+0·117	+0·39
2324	24 Sagittarii	−0·005	+0·01
2326	25 Sagittarii	+0·009	−0·03
2342	2 Aquilæ	0·000	0·00
2357	6 Lyræ ζ^1	+0·003	−0·02
2358	Lyræ ζ^2	+0·003	−0·02
2380	11 Lyræ δ^1	−0·001	·00
2383	12 Lyræ δ^2	−0·002	−0·01
2404	50 Draconis	−0·016	−0·07
2409	Bradley 2409	—	−0·02
2427	20 Lyræ η	0·000	−0·01
2443	55 Draconis	—	−0·01
2428	1 Vulpeculæ	0·000	0·00
2446	49 Sagittarii χ^1	−0·003	0·00
2471	58 Draconis π	—	−0·03

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
2477	37 Aquilæ κ	0·000	0·00
2484	41 Aquilæ ι	0·000	0·00
2498	13 Cygni θ	−0·002	−0·24
2499	6 Sagittæ β	0·000	+0·04
2503	14 Cygni	+0·002	−0·05
2514	15 Cygni	+0·006	−0·04
2517	17 Cygni χ	0·000	+0·44
2518	52 Aquilæ π	0·000	0·00
2523	8 Sagittæ ζ	+0·003	−0·04
2537	13 Vulpeculæ	+0·001	−0·04
2548	21 Cygni η	−0·003	+0·03
2553	14 Vulpeculæ	−0·007	−0·02
2559	Bradley 2559	0·000	0·00
2568	15 Sagittæ	−0·029	+0·37
2591	4 Capricorni	+0·001	+0·03
2602	23 Vulpeculæ	−0·004	−0·01
2606	24 Vulpeculæ	+0·001	+0·03
2612	32 Cygni	+0·001	0·00
2625	39 Cygni	+0·004	−0·01
2633	69 Aquilæ	+0·003	−0·01
2637	41 Cygni	+0·001	0·00
2645	45 Cygni ω^2	+0·001	−0·01
2642	2 Delphini ε	0·000	+0·03
2647	46 Cygni ω^3	+0·002	+0·05
2651	2 Cephei θ	+0·005	+0·05
2657	15 Capricorni υ	−0·003	−0·01
2662	8 Delphini θ	−0·001	+0·01
2682	73 Draconis	+0·001	+0·02
2704	75 Draconis	+0·009	−0·01
2692	54 Cygni λ	−0·002	−0·01
2693	15 Delphini	+0·002	−0·10
2700	19 Capricorni	−0·005	+0·01
2720	Bradley 2720	—	−0·03
2713	20 Capricorni	+0·001	+0·02
2727	Bradley 2727	—	+0·03
2718	21 Capricorni	−0·003	−0·01
2748	Bradley 2748	—	−0·05
2737	24 Capricorni A	−0·003	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	"
2747	13 Aquarii ν	+0·005	0·00
2751	5 Equulei γ	+0·004	+0·17
2758	28 Capricorni ϕ	+0·009	0·00
2761	7 Equulei δ	+0·011	+0·29
2769	67 Cygni σ	0·000	+0·02
2773	Bradley 2773	−0·002	—
2776	17 Aquarii	−0·004	+0·02
2788	6 Cephei	0·000	+0·01
2782	19 Aquarii	−0·001	+0·17
2805	7 Cephei	−0·002	+0·03
2813	4 Pegasi	+0·007	−0·04
2820	42 Capricorni	−0·013	+0·30
2819	41 Capricorni	+0·007	+0·11
2823	44 Capricorni	−0·002	−0·03
2834	46 Capricorni c^1	−0·003	−0·02
2837	9 Pegasi	+0·002	0·00
2842	Piscis Australis θ	−0·006	0·00
2859	14 Pegasi	+0·001	+0·03
2864	16 Pegasi	0·000	0·00
2873	12 Piscis Australis η	0·000	0·00
2883	31 Aquarii o	0·000	0·00
2891	22 Pegasi ν	+0·006	−0·11
2906	18 Cephei	+0·001	...
2907	17 Cephei ξ	—	−0·07
2908	37 Aquarii e^1	+0·003	−0·05
2909	38 Aquarii e^2	+0·002	−0·01
2922	16 Piscis Australis λ	+0·001	+0·03
2933	1 Lacertæ	+0·001	0·00
2936	45 Aquarii	+0·004	0·00
2941	30 Pegasi	0·000	0·00
2940	47 Aquarii	−0·003	+0·07
2944	31 Pegasi	0·000	−0·01
2949	50 Aquarii	+0·002	−0·02
2958	4 Lacertæ	−0·002	+0·02
2959	35 Pegasi	+0·004	+0·30
2969	26 Cephei	−0·003	+0·02
2970	5 Lacertæ	−0·002	+0·02
2967	58 Aquarii	+0·004	+0·02

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
2971	6 Lacertæ	−0·002	—
2980	28 Cephei	−0·009	+0·07
2976	59 Aquarii *υ*	+0·015	+0·16
2988	29 Cephei *ρ*	—	+0·03
2995	11 Lacertæ	+0·008	−0·01
2991	19 Piscis Australis	−0·002	—
3001	67 Aquarii	−0·003	−0·02
3008	46 Pegasi *ξ*	+0·014	+0·48
3010	47 Pegasi *λ*	+0·004	+0·01
3012	70 Aquarii	+0·003	−0·03
3023	15 Lacertæ	+0·010	−0·01
3028	Bradley 3028	—	−0·03
3021	74 Aquarii	+0·001	+0·01
3040	81 Aquarii	−0·002	+0·01
3042	82 Aquarii	−0·001	+0·03
3048	83 Aquarii *h*¹	+0·008	−0·02
3054	Bradley 3054	—	0·00
3056	55 Pegasi	−0·001	+0·01
3057	56 Pegasi	0·000	+0·03
3059	5 Piscium A	+0·008	−0·13
3062	88 Aquarii *c*²	+0·002	−0·05
3065	89 Aquarii *c*³	−0·004	+0·01
3105	98 Aquarii *b*¹	−0·012	+0·10
3113	99 Aquarii *b*²	−0·005	+0·06
3125	Bradley 3125	—	+0·01
3122	70 Pegasi *q*	+0·002	−0·03
3130	101 Aquarii *b*⁴	−0·004	−0·11
3147	Bradley 3147	+0·086	0·00
3145	102 Aquarii *ω*¹	+0·003	+0·04
3150	103 Aquarii A¹	−0·004	+0·08
3151	104 Aquarii A²	+0·002	−0·02
3159	106 Aquarii *i*¹	+0·001	+0·02
3160	78 Pegasi	+0·006	+0·03
3162	19 Piscium	−0·004	+0·02
3166	Bradley 3166	—	+0·01
3167	21 Piscium	−0·001	+0·01
3174	22 Piscium	+0·001	+0·01
3183	26 Piscium	+0·001	+0·01

No. in Bradley (1755).	Star's Name.	Proper Motion in R.A.	Proper Motion in N.P.D.
		s	″
3195	Bradley 3195	—	+0·02
3200	31 Piscium c^1	−0·001	+0·01
3201	32 Piscium c^2	−0·005	+0·03
3212	Bradley 3212	—	+0·18

ι Aurigæ. The R.A. of the Fundamenta is 1′ too large.
Bradley 1458. The places given in the Fundamenta are in error.

On the Periodic Time of α Centauri. By E. B. Powell, M.A.

For the last four or five years I have been led to believe that the period of α *Centauri* has been considerably underestimated by calculators of orbits for that binary, myself included; and I now beg to lay before the Society the grounds on which I have come to this conclusion. Dr. Elkin's orbit and Mr. Downing's modification of the same no doubt accord very closely with observations between 1834 and 1877, and I imagine only comparatively slight changes will be found requisite in regard to all the elements save the period. The comes has been watched pretty closely through a change of position angle of more than 330°, corresponding to a change of true anomaly of more than 250°. The question now is, how far the apparent or perspective orbit runs out in the south-preceding direction. In connection with this point I propose to refer to some early notices of the star.

I believe the earliest observation of α *Centauri* is one by Father Richaud, recorded in observations, mathematical and physical, sent by certain Jesuit Fathers to the Royal Academy of Sciences at Paris, and published in 1692. In this work occurs isolated Richaud's note, which is as follows:—

"Regardant à l'occasion de la comète plusieurs fois les pieds du *Centaure* avec une lunette d'environ douze pieds, je remarquai que le pied le plus oriental et le plus brillant étoit une double étoile aussi bien que le pied de la croisade; avec cette différence que dans la croisade, une étoile paroît avec la lunette notablement éloignée de l'autre; au lieu qu'au pied du *Centaure*, les deux étoiles paroissent même avec la lunette presque se toucher; quoique cependant on les distingue aisément."

Richaud observed the comet referred to at Pondicherry in December 1689; hence the epoch of his observation may be taken approximately as 1690. The components of α *Crucis* spoken of are, I imagine, not the two close stars, but those two seen as one and the third—a sixth magnitude star. The close stars are about 5″ apart, while the third is about 90″ distant from the close one. The near stars, if moving, are moving very slowly, though the recorded measures of distance in this century,

supposing they can be relied on, indicate a decrease of that quantity. The use of the word "notablement" supports my view. Now we have Newton's remark in the "System of the World," that in his time the brighter fixed stars appeared through the telescope with a good full light to be 5″ or 6″ in diameter, and that with a fainter light they ran out to a greater breadth. Taking this remark into account it seems probable that the distance of *α Centauri*, as measured in the modern manner from centre to centre of the components, did not in 1690 fall short of 7″, and probably was in excess of that angle. But by forming a table showing the distances, on hypothetical periods ranging through 76, 77, &c., years, as determined by distance measures in the present century, we find that periods of 80, 81, &c., to 86 years are inadmissible in consequence of affording distances below 7″. Thus a period of 80 years would for two revolutions from 1690 bring us to 1850, when the distance was about $6\frac{3}{4}''$; and a period of 81 years in the same way would bring us to 1852, when the distance was $5\frac{1}{2}''$. These considerations seem to bar any period between 80 years and 86 years. It is true, however, that the grounds on which this conclusion is based are not certain ones, and that consequently we cannot do more than attribute a measure of probability to it.

The next notice of *α Centauri* to which I wish to call attention is one carrying much more weight. It is that by Father Louis Feuillée, described as "Religieux Minime, Mathématicien, Botaniste de Sa Majesté, et correspondant de l'Académie Royale des Sciences." The note is in the *Journal of Observations, Physical, Mathematical, and Botanical*, made by order of Louis XIV. between 1707 and 1712. The journal was published in 1714, and the observation was made at Lima on July 4, 1709. The notice is as follows:—

"Sur les deux heures du matin, en attendant que je pusse observer l'émersion du premier satellite de *Jupiter*, que des nuages me cachèrent, j'observai avec une lunette de 18 pieds l'étoile de la première grandeur qui est au pied boréal du devant du *Centaure*; je trouvai cette étoile composée de deux, dont l'une est de la troisième grandeur et l'autre de la quatrième. Celle de la quatrième grandeur est la plus occidentale, et leur distance est égale au diamètre de cette étoile."

There are two points to be noticed in the above extract. First, the comes is declared to have been west of the primary; and secondly, the distance is said to have been equal to the diameter of the comes. We now know that the far larger portion of the orbit of *α Centauri* lies to the west of the meridian through the primary, the eastern portion having been described in the interval between about 1862·7 and 1879·9, or approximately 17 years. It follows, therefore, that if Feuillée's observation be correct, viz. that in 1709·5 the smaller star was west of the larger, the period must either fall short of $\frac{1}{2}$(1862·7 —1709·5), *i.e.* 76·6 years, or must exceed $\frac{1}{2}$ (1879·9—1709·5),

i.e. 85·2 years, any intermediate value being out of the question. It appears highly improbable that an experienced observer such as Feuillée was could have made the mistake of turning east into west; and unless such a mistake was made, the observation must be regarded as of the highest importance. If, as I now believe, so short a period as 76·6 years will not allow of the requisite extension of the orbit of *α Centauri* in the south-preceding direction, it follows that the period must exceed 85·2 years.

Turning to the second point in Feuillée's notice, viz. the apparent distance of the components, and assuming that the distance he referred to was the interval between the apparent disks of the stars, the distance between the components from centre to centre could not well be less than $3'' + 2\frac{1}{2}'' + 5''$, *i.e.* $10\frac{1}{2}''$. But forming a table similar to that spoken of when discussing Richaud's observation, we find that such a distance is incompatible with any period between 79 or 80 years and 87 years.

Summing up the results for both Richaud and Feuillée, and even allowing for error in estimating the apparent diameters of the stars, I think the observations of those astronomers, taken with the presumed necessity of allowing a greater extension to the orbit in the south-preceding direction than is compatible with a period of 76·6 years, point strongly to the time of revolution not falling short of 86 or 87 years.

Some three years ago I found that a period of over 89 years, with a semi-major axis of above 18″, and other elements but little different from those already arrived at, afforded results, certainly not in good accordance with observation, but still not offensively discordant save in the case of the epoch 1877·6, when θ_o differed from θ_c by nearly 6°. I do not, however, believe that the period can be so large, and I merely mention the circumstance to show that so great an extension of the time of revolution does not destroy the correspondence of the computed and the observed motions. Last year, after various trials, I arrived at an orbit with a period of 86·56 years, which agreed with observation to within 1° of position angle for all the measures (14 in number) which I put in comparison from 1834 to 1876; from 1876 to 1881 the values of $(\theta_o - \theta_c)$ were larger but not excessive except in the case of the epoch 1878·38, for which the value was 7°·25, the errors for 1880 and 1881 again falling below 1°. Curiously enough the orbit to which I refer made the value of $(\theta_o - \theta_c)$ for 1878·185 only −0°·2, while Mr. Downing considers θ_o for that date to be very considerably in error. The components were so close to one another in 1877 and the early part of 1878 that errors of some magnitude could scarcely be avoided, especially as the stars are large; and probably it will be advisable to defer making further orbital calculations till three or four years additional measures will, as it were, allow the observations taken in 1877 and 1878, near the lesser minimum distance, to be given only a secondary influence in

determining the elements. I trust the points I have noticed above, some of which I have touched on in an incidental manner in former papers, will be considered to possess some interest; and I observe that in the remarkable papers lately put forward by Drs. Gill and Elkin upon the parallax of *a Centauri* it is stated that those astronomers saw reason to conclude that the period of *a Centauri* must be longer than the value originally assigned by Dr. Elkin.

In arriving at the orbits formerly submitted by me, I placed great reliance upon Maskelyne's observation at St. Helena in July 1761, according to which the distance was then between 15″ and 16″. The measure was made with a divided object glass micrometer fitted to a reflecting telescope by Short. On hearing, through a common friend, that I was anxious to obtain information regarding this observation, the present Astronomer Royal was kind enough to send me a copy of certain entries in Maskelyne's manuscript note-book referring to measures taken with the above micrometer. From the entries I find that, while Maskelyne made the distance for *a Centauri* to be 15″·6 by two measures, he brought out on the same night the distance of the comes of *β Scorpii* as 7″·2 by one measure. In regard to the latter, he states it was much less exact than the distance measure of *a Centauri*, and he remarks that no observation of distance "of this kind" can be taken very precisely. It may be noticed, in passing, that on the same night the micrometer gave 11″ as the diameter of the disk of *Arcturus*. Now it happens that from the *Philosophical Transactions* of the Royal Society, vol. liv., we learn that in August 1761, while at St. Helena, Maskelyne measured with great care, with a 10-ft. sector, the difference of declination of the two stars of *β Scorpii*, and made it by the mean of six nights to be 13″·97. From this it becomes evident that no reliance can be placed upon the distance measures with the object-glass micrometer, as that apparatus actually made the distance little more than one-half the difference of declination, or in other words, made the hypotenuse of a right-angled triangle only a trifle greater than half one of the sides. In these circumstances it seems clear that we must set aside Maskelyne's distance measure of *a Centauri*, although it was taken with greater care than that of *β Scorpii*, the former being the mean of two observations, and the latter only a single measure; the micrometer was in fact so imperfect in its nature as entirely to vitiate the results. And it is to be recollected that Maskelyne's distance measure was one of the chief supports (in my eyes the chief one) of the short period of seventy-six years or thereabouts.

It must be allowed that La Caille's measures of difference of Declination and difference of Right Ascension do not support so long a period as 86 or 87 years; but his apparatus, however carefully and skilfully used, was certainly not competent to deal at all accurately with seconds of space; therefore the results

arrived at by this astronomer cannot be permitted to guide us in the present question.

Fallows had also very inadequate instruments to work with, consequently much weight cannot be attached to his measures; but, so far as they go, they suggest a *very* considerably greater elongation in the south-preceding direction than Dr. Elkin's orbit would allow, in fact a greater one than even now seems to be warranted by the circumstances I have dwelt on above. I may mention that the measures of Rümker and Dunlop also indicate that the orbit runs out tolerably far in the south-preceding direction.

On the whole I cannot but think it highly probable that the apparent orbit is considerably larger than has been supposed, and that the period may embrace some 86 or 87 years.

Hampstead:
1884, *Nov.* 12.

Note on Stellar Photography. By A. A. Common.

Photography, as a means of charting the stars in a rapid and most accurate manner, is now, through the introduction of the gelatine dry plate, likely to come into extensive use, if it does not entirely supersede the old method of eye observation of each separate star. Its power to picture the stars in their proper relative positions and magnitudes in a way that is free from personal error, and under conditions that can be easily and certainly reproduced at any future time, renders the work done in this way so valuable in many investigations, that it is hardly possible to properly estimate it, while the much greater amount of work that can be done will render it still more valuable.

As is well known, photographs of double stars and clusters of stars have been made many years ago, but from the difficulties in connection with the use of the wet plate process then generally employed, the results were not very great in comparison with the trouble that was required. A negative of the *Pleiades*, now in possession of this Society, by Rutherfurd, is perhaps one of the best photographs by this old process.

Many other photographs have been taken from time to time in this manner, but it is but recently that the practicability of taking large fields with comparatively small apertures has been shown.

Attention was, I believe, first drawn to this by the remarkable photographs of the great comet of 1882 that were taken at the Cape and sent home by Dr. Gill. Through the kindness of Dr. Huggins I saw one of these photographs very soon after it came to England, and I must say that I was extremely surprised at the number of stars that were shown. It is true that they were large and ill-defined, particularly at the edge of the plate, but

there they were, and that was the great thing, considering that only an ordinary portrait lens had been used.

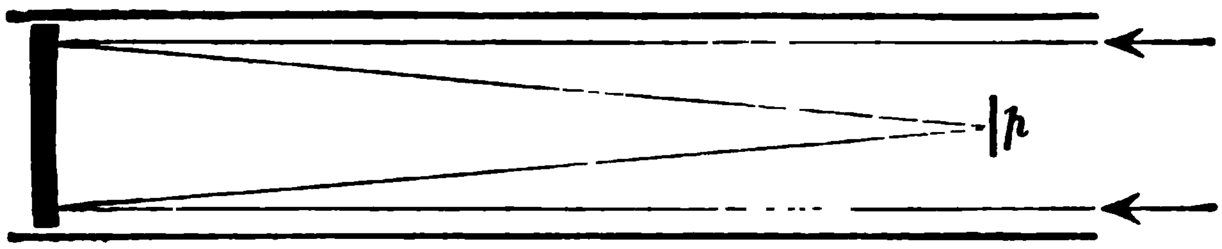
I had in 1879, in the course of experiments with the 3-foot telescope, taken pictures of the *Pleiades* with $1\frac{1}{2}$ minutes' exposure, using the gelatine dry plates then being introduced, that showed stars of the 8th and 9th magnitude.

These comet photographs, however, opened out a new way that I was not slow to follow. I was then (in 1882) working at the photographs of the nebula in *Orion*, devoting every fine night to that purpose. One evening when thus working I attached a small camera to the mounting of the large telescope, and with a lens of about $\frac{3}{8}$-inch aperture I exposed a plate for twenty minutes—the time I was then giving to the plate in the large telescope. The result of this first experiment with small aperture was most surprising. The stars that form the figure of *Orion* were there, and stars in the centre of the field to about the 9th magnitude, and a portion of the nebula itself. The stars near the edge were a little oval, but not very objectionably so. I did nothing further just then, but determined to follow the matter up by more experiments. For this purpose I completed a 6-inch refractor by February 1883, with a mounting specially made to carry cameras on the declination axis; and through the kindness of Messrs. Ross, the opticians, I tried almost every kind of lens that is made for photography. Judging by the picture already mentioned, I had contemplated as possible a field of at least 10° without altering the perfectly round shape of the stars, or losing too much light at the edge of the field; but the results of many experiments with symmetrical, rapid symmetrical, landscape, portrait, and other lenses was not favourable. Some gave better fields than others, but the amount of astigmatism and loss of light away from the centre was greater than with the first small lens. I came to the conclusion that with the best ordinary lens it would not be safe to rely on more than 4° or 5° of the centre of the field for freedom from astigmatism and equality of illumination. Messrs. Ross told me they could make a special lens that would be very much better, but I have not yet learnt that anything has been done by them.

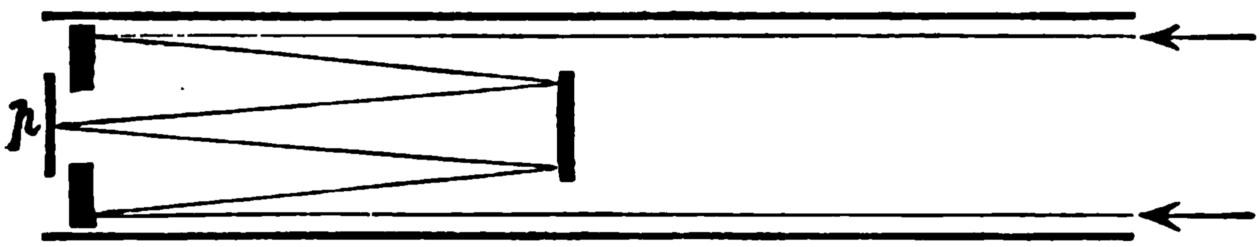
I have brought here to-night a picture of part of *Orion* taken during these experiments; it is cut out of the centre of a larger plate, but it shows what can be done with such lenses as those I have named. A comparison with Argelander's Atlas shows that some of his 9th and 10th mag. stars are shown, and that in several cases there is considerable difference in positions and magnitudes. I have also brought a picture of the *Pleiades* taken with a lens of 4-inch aperture and about 2-feet focus, and one of the plates taken with the very small lens. In using photography, the first thing would naturally be work in some plan that would allow a series of pictures to be taken of the whole heavens on as large a scale as it could be done on in a reasonable time; for this purpose the lens appears the most suitable, leaving the reflector

for large pictures of objects of interest, such as nebulæ, clusters, &c. The difficulty with the lens has, however, led me to consider how the reflector might be utilised; the ordinary arrangement does not lend itself to large fields, but from various experiments I have reason to think that it *is* possible to use the reflector for this purpose. The choice seems to me to be practically between three different arrangements: the first is when the sensitive plate is placed in the principal focus, directly in front of the large mirror; the second is a modification of the Cassegrain telescope (amounting almost to a new form) made by increasing the size of the small mirror to one half or even more

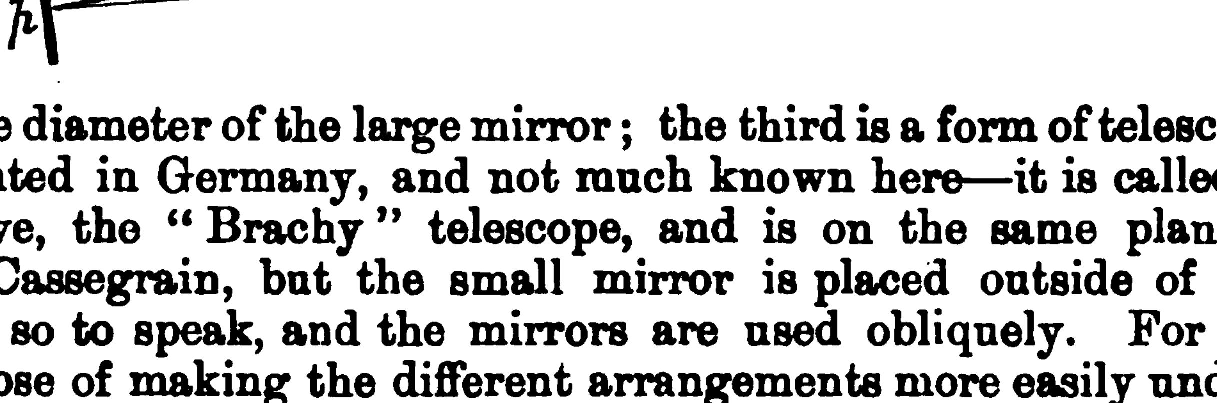
1.



2.



3.



of the diameter of the large mirror; the third is a form of telescope invented in Germany, and not much known here—it is called, I believe, the "Brachy" telescope, and is on the same plan as the Cassegrain, but the small mirror is placed outside of the tube, so to speak, and the mirrors are used obliquely. For the purpose of making the different arrangements more easily understood, I have given an outline sketch of each that will show at once the distinctive differences between them. The first arrangement has simplicity to recommend it, and as a large telescope I can imagine nothing better. There is only one surface, so that the greatest possible amount of light is used effec-

tively, and it is symmetrical; for this work, however, where flatness of field is necessary, I do not think it can be so good as either of the other forms. The second arrangement is peculiar, and with a mirror of 5-foot aperture the supports of such a second mirror might be difficult; on the other hand, the loss of reflecting surface can be made up by a trifling increase of diameter in comparison with other forms. The connection between the mirrors can be made very rigid as they are so near, the surfaces can be wrought to suit each other and to give a flat field in addition, all is symmetrical, and that is important, and the plate is in a convenient place for exposure under examination, and is quite protected by the smaller mirror from the direct light of the sky.

The largest instrument of this kind that I have tried has a concave mirror of 9½ inches, and a smaller mirror of 4½ inches diameter; the focal length of large mirror is 43 inches. This instrument, roughly mounted in a wooden box, and attached to the 6-inch telescope, forms a photographic telescope that will give a picture of an 11 mag. star in thirty minutes under very unfavourable circumstances. The field of view is 3° only, as the hole that I cut in the large concave is not larger, but as far as it goes it is good. Altogether the arrangement has been more satisfactory than I expected, and I intend to try larger sizes to see if any new features become developed.

The third arrangement I have not tried with photography, but it is quite possible that it may be the best for this purpose. I have tried it on artificial stars, and the way in which the second mirror corrects the astigmatism due to the oblique position of the large one is most remarkable. I cannot find very much information about it, though, no doubt, some exists. I mention it and the other form in the hope that some one may make some trials of it for photography, as it is important to have all the information possible as to the best kind of telescope for this purpose, and this can be best done by many independent experiments. It appears to me that the aim ought to be the production of photographic charts made up of separate fields of 4°, 5°, or 6°, or even more if it be possible, on a scale at least twice that of Argelander's Atlas, and including stars of the 12th magnitude, and this with a moderate exposure.

I believe this, and more than this, to be now possible, but it is necessary that the best way to do it should be clearly shown.

Note on a Method of giving Long Exposures in Astronomical Photography. By A. A. Common.

In exposing a sensitive plate for a long time the image is liable to shift, from the driving clock not keeping pace with the diurnal motion, from change in the apparent place of the object due to refraction, from change in the position of the focal plane

due to alterations of temperature, and in the case of reflectors from changes of position of the mirrors due to different strains coming into play as the telescope moves round. None of these movements are very large or come into play quickly, but if allowed to act without immediate correction they will spoil the picture.

In the case of small instruments it is only necessary to watch the object in the finder, and use the fine movements of the telescope as required; but in large heavy instruments, and particularly in the case of reflectors, this cannot be done, the connection between the finder and the mirrors being at all times bad. When using a large reflector for long exposures, as in taking the nebula photographs, I used an apparatus that I devised for watching and correcting any errors of movement in the telescope, which is so simple and efficient, that a description may be useful to those who contemplate work similar to that for which I used it. In this case the image of a star as near as may be to the object to be photographed, formed by the same mirror as produces the picture, was observed, and by means of cross-wires attached to the same slide that held the plate, and moving with it, the cross-wires and the plate were kept constantly in one position with regard to this star, and consequently to the image falling on the plate.

The general arrangement may be thus described. On the tube that fits the eyepiece end a plate is fixed, carrying two slides capable of movement by means of fine screws in directions at right angles, in the manner of the ordinary slipping piece in use with a micrometer. The upper slide is for carrying the plate holder, and has two screws to hold it in position. A box is fixed to this slide to carry the cross-wires and eyepiece; in the box there are three grooves—the lower one carrying the cross-wires, the next a plate of glass to protect them from the breath of the observer, and the other to carry the eyepiece. The cross-wires and the eyepiece can be placed at any point in the length of the box so as to be more easily placed on a suitable star. A lamp is attached to the end of this box to illuminate the cross-wires in the usual manner. If through any cause it is necessary to interrupt the exposure, it is only necessary to close the shutter of the plate-holder, and then before opening it again to see that the cross-wires are exactly on the image of the star. I have often had to so interrupt a long exposure, but I have never found that the apparatus failed to act perfectly.

I do not think that long exposures can be made, especially with reflectors, without some such arrangement as this to prevent injurious shift of the image; and the larger the telescope the more important it would become, as the movements due to the strains in the mounting would be greater. It becomes, therefore, interesting to consider how this could be done in the case of a large reflector when it is determined to place the plate in the centre of the tube (using this word in its proper sense as

applied to reflectors) at the principal focus of the great mirror, and work the correcting apparatus from below, entirely dispensing with any platform or tower for the observer. This arrangement would be the most simple and probably the best that could be used; there would be but one reflecting surface, and everything would be symmetrical. To work the apparatus for correcting during exposure by keeping the cross-wires rigidly on the star, to open and close the shutter, and, above all, to exactly focus the plate, seems at first a difficult thing to do by an observer placed, it may be, fifty or sixty feet away; but by means of small electro-motors these things can be easily done. There is of course behind the plate a good deal of space available for the mechanical arrangements, and the details would not offer any difficulty to any one to work out; and as the power would be conducted by thin wires, much less obstruction would be offered by these than by any other merely mechanical arrangement; in fact, the wires that support the apparatus would do for the conductors. With the optical arrangement that would be necessary there would not be any particular difficulty.

The two things that are required are, that the focussing be accurately done, and that the image of the cross-wires and the star should be as plainly seen by the observer on the ground, as if he were observing them with an eyepiece directly. If the power is sufficient, the same apparatus that is used to observe the star and wires will do to focus the plate by simply focussing the star accurately, and then moving the wires previously adjusted to the same plane as the sensitive plate, until they are also in focus.

There are several ways in which this could be done. The simplest would be to fix two right-angled prisms, one on the apparatus behind the cross-wires, where the eyepiece is in the aforesaid arrangement, and one outside the tube in a similar place to the eyepiece in a Newtonian reflector, so that an object-glass of 4 or 6-in. aperture placed at its focal distance from the image of the cross-wires would send the collected rays on, parallel to another object glass near the lower end of tube, that would bring them to a focus in a convenient place for observation. There are of course other optical arrangements that would do, but this would, I think, be found to answer well.

Ealing: 1884, *Nov.*

A Remarkable Configuration of Stars in the Milky Way detected by Photography. By Rev. T. E. Espin, B.A.

In October last year some experiments were undertaken by me with a view to photographing large fields of stars, and reducing the photographic magnitudes from the plates. By the courtesy of Professor E. C. Pickering I was allowed to see the negatives that he had with him during his visit to Europe. Early in

October 1883 a camera with a lens of 2½-in. aperture was mounted on an equatorial stand at West Kirby, and several negatives were obtained. Two were exhibited at the November meeting of the Liverpool Astronomical Society, and the council determined to solicit subscriptions for erecting a large equatorial stellar camera. In the mean time Mr. Howard Grubb, taking a kindly interest in the work, generously placed at my disposal a powerful instrument at a nominal cost. This instrument was erected in March at West Kirby. It is an equatorial stellar camera with a compound lens of 4½-in. aperture, and 15·8 in. focal length. The equatorial is driven by clockwork.

The line of research which I proposed to undertake was two-fold: (1) The determination of the star magnitudes from the photographs; and (2) the solution of the problem of charting parts of the heavens by photography. The preliminary results of the first part of the research were published last May as *Transactions* No. 3 of the Liverpool Astronomical Society. The second part is more difficult, and till a few weeks ago nothing satisfactory had been accomplished. Some excellent negatives had been obtained, but all attempts at printing from them were failures. The fainter stars in the negatives were not reproduced on the prints. Slow printing and rapid printing were alike useless in this respect, and I had given it up in despair, when the discovery of the remarkable "horseshoe" configuration in *Cygnus* again led me to desire greatly to print from the negatives.

It suddenly struck me that it might be possible to enlarge the images and photograph them; and that then negatives might be obtained which it would be possible to print from. After one or two attempts I was successful, and in printing from the enlargements I found that the faintest detail in the original negative was readily reproduced on the print.

The print that I have the honour to present to the Society* was obtained from an enlargement of a negative taken with the camera on Sept. 20 with one hour's exposure. The plate used was one of Wrattan and Wainwright's "drop-shutter" plates, which I have found to be the most rapid of any obtainable.

The night was remarkably clear, and the exposure from half an hour before to half an hour after meridian passage.

The remarkable configuration of stars photographed on the plate includes five of Argelander's stars.

The number and places of these are as follows, as taken from Argelander:—

D.M. + 46°3188	XXI.	2 13·6	+ 46	39·5	9·2
D.M. + 46·3191		2 21·2		41·5	7·7
D.M. + 46 3192		2 34·7		43·4	8·7
D.M. + 46·3193		3 27·1		40·2	7·7
D.M. + 46·3201		3 54·2		40·7	7·1

* The print may be seen in the Society's library.—Ed.

The remaining eleven stars are not in Argelander.

The smallest star photographed is probably not much above the 11th mag. Looking at the field with a 5-inch refractor, many of the stars seemed minute. On the focussing glass of the camera the Milky Way appeared as a bright glow, and this is plainly visible as a bright nebulosity on the print.

A Photometric Comparison of the Light transmitted by certain Refracting and Reflecting Telescopes of Equal Aperture. By Prof. C. Pritchard, D.D., F.R.S.

In a communication to the Society respecting the Oxford observations of stars occulted by the Moon during its recent total eclipse, I had occasion to mention the occultations of four faint stars, three of them approaching the twelfth magnitude, and not included in Dr. Döllen's list, and not found in any catalogue with which I am acquainted. Of these four stars one only was distinctly seen in the De la Rue Reflector of 13-in. aperture, although the other three were sufficiently salient to admit of observation during the eclipse by the Grubb Refractor of $12\frac{1}{4}$-in. aperture, and of their subsequent identification by means of that instrument.

This circumstance directed my thoughts once more to the long-agitated question concerning the relative light capacities of reflecting and refracting telescopes of approximately equal aperture. There being "nothing new under the Sun," I half expected to find that the question had long since been finally settled, and that there was no need of further research. On inquiring in those quarters where I thought the information, if it existed, would be possessed, and on referring so far as I could to written authorities, I came to the conclusion that the comparisons in question had up to the present time been conducted on insecure bases, and in fact were simply conjectural. Dr. Robinson, the late distinguished astronomer of Armagh, and who, I believe, would be admitted to be among the most reliable authorities on the question, thus writes in the *Monthly Notices* for May 1876:—"William Struve thought that the Dorpat Telescope of 9·6-in. aperture might be compared to Herschel's 20-ft. Reflector of 18-in. aperture;" and he adds, "We are told that M. D'Arrest's Achromatic of 11-in. aperture is very superior to Herschel's 20-ft. Telescope, and almost equal to the great telescope of Lord Rosse." Again, in the *Philosophical Transactions* for 1869 we find the same high authority, in his memoir on the great Melbourne Telescope, writes as follows:—"If we seek any comparison of the light of the two kinds of telescopes, based on actual measures, little is to be found but vague conjectures; thus M. Otto Struve *thinks* that Mr. Lassell's Telescope of 2-ft. aperture is nearly equal to the light of the Pulkowa 16-in." Dr. Robinson, in the *Monthly Notices* already cited, goes on to express

a hope that as the Paris Observatory would soon be in possession of two magnificent instruments of both kinds, the question of their relative light capacity would soon be set at rest. I am not aware that this hope has been practically realised. Moreover, I believe that a committee was appointed by the British Association for the prosecution of a kindred inquiry, but I cannot find that a report has been actually published on the subject.

In the middle of these wide, not to say somewhat wild, conjectures, it occurred to me that the Observatory under my direction at Oxford is in possession of a photometer especially adapted to the determination of the question at issue; and, thanks to the generosity of Dr. De la Rue, possesses also two mirrors—the one of metal, which has done such excellent work in the hands of its donor, and also a silver-on-glass speculum (by With) of the same dimensions and of nearly equal excellence. With these means before me I determined to make the necessary measures, with a strong expectation of success.

Accordingly, immediately after the eclipse referred to, I requested my two able assistants, Mr. Plummer and Mr. Jenkins, whose experience now extends over many thousand photometric measures, to prepare a convenient list of stars, varying in magnitude from the second to the sixth, and, by means of them, measure their relative light-intensities as transmitted by the three instruments, viz. the Grubb Refractor of 12¼-in., and the two mirrors of about the same aperture, and already described.

The process which I arranged was as follows:—

Each of the two observers, armed with his own wedge photometer with its eyepiece attached, observed on it the point of extinction of each of the selected stars in each of the three instruments. Five extinctions were observed in the case of each star, and the resulting mean was adopted. From these data the relative light capacities of the three instruments were computed, on the principles and after the manner indicated in my memoir in the 47th volume of our Society's *Transactions*.

The observations made by Mr. Plummer and Mr. Jenkins possess the same degree of close accordance which has hitherto characterised their photometric work, and leave no doubt on my mind as to the accuracy of their conclusions.

The results are as follows:—

Light transmitted by the Grubb Refractor, 12¼-in. aperture	:	Light transmitted by the De la Rue Reflector 13-in. aperture	:: 1·89 : 1
Light transmitted by the Grubb Refractor, 12¼-in. aperture	:	Light transmitted by the silver-on-glass mirror 13-in. aperture	:: 1·5 : 1

The average deviation of the individual measure from the adopted mean does not exceed the light indicated by about $\frac{1}{20}$th of a "magnitude" on Pogson's scale.

It ought here to be remarked that the De la Rue metallic

mirror has now been in constant use for upwards of thirty years, though still in a very serviceable condition. The silver-on-glass speculum, by With, is in a high state of polish; moreover, it has long been known that the reflective power of silver exceeds that of speculum metal, and this also no doubt is the case (though possibly not to an equal extent) with chemically deposited silver on glass.

Further, it will be observed that I have not here entered upon the general question of comparing achromatic object glasses with mirrors, whether of speculum metal or of deposited silver; I have confined the question to the large telescopes with which I am necessarily familiar, though I have little doubt they may be regarded as representative instruments. It is probable that no two object glasses, and no two mirrors, will be strictly alike in respect of light capacity, though possessing a general family likeness.

Nor have I here attempted to obtain the ratio of the amount of the light incident on the mirror or the object glass to that which is reflected from, or refracted through it, simply as a mirror or an object glass; therefore I do not touch on the question of the relative photographic values of the two kinds of instruments; but I repeat that I have confined my investigation to the relative amounts of light passing through the eye-lenses of the respective instruments. I am here treating of three telescopes and not of photographic cameras; still less am I here pretending to decide as to the relative superiority of the two forms of telescope. There are, however, two important remarks made by the late Dr. Robinson in the *Monthly Notices* to which I am disposed to give my entire assent. The one is, that in proportion as the apertures of the two sorts of instruments are greatly increased, the superiority of the light-transmitting power of the Refractor becomes less and less over that of the Reflector. Few persons are probably aware of the considerable loss of light in its passage through an object glass, on account of surface reflections and absorption of light by the materials. The latter loss of light increases, after a geometrical ratio, with the thickness of the glass; and this augmentation of thickness also necessarily increases at a rapid rate with any increase of aperture. From this peculiar idiosyncrasy reflectors are free; and no doubt if it were possible to sufficiently increase the aperture of an object glass, there must at length arise a thickness of glass material which will absorb more light than is lost by reflection from the speculum. This limit, however, is probably practically unattainable by any otherwise good object glass capable of being manufactured and figured; whereas the possible limits to the aperture of a reflector are at present not only not attained, but even as yet unsuspected. I agree consequently with the eminent philosopher of Armagh in the opinion that attention may in future be most profitably directed to the increase of the aperture of mirrors whether parabolic or plane, for the extension of our knowledge in astronomical physics.

The following Tables contain the particulars of the individual measures on which the results referred to in the foregoing statements are founded.

TABLE I.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-*in. aperture and the De la Rue Reflector of* 13-*in. aperture.*

Star selected.	Tabular mag. of Star selected.	Diff. of Light expressed in mag. Wedge A.	Ratio of the Lights transmitted.	Diff. of Light expressed in mag. Wedge B.	Ratio of the Lights transmitted.
β Andromedæ ...	2·2	0·76	2·01 : 1	0·68	1·87 : 1
g Pegasi ...	2·5	0·61	1·76 : 1	0·70	1·91 : 1
θ Andromedæ ...	4·5	0·75	2·00 : 1	0·83	2·15 : 1
32 Andromedæ ...	5·5	0·63	1·79 : 1	0·70	1·91 : 1
75 Piscium ...	6·2	0·67	1·85 : 1	0·68	1·87 : 1
Mean ...		0·684	1·88 : 1	0·718	1·94 : 1
		Av. dev. $0^m·06$		Av. dev. $0^m·05$	

TABLE II.

Comparison of the Light transmitted by the Grubb Refractor of 12¼-*in. aperture and the De la Rue Telescope with the Silver-on-Glass Mirror (With), also* 13-*in. aperture.*

α Aquarii ...	3·0	0·47	1·54 : 1	0·49	1·57 : 1
π Pegasi ...	4·1	0·40	1·45 : 1	0·42	1·47 : 1
59 Pegasi ...	5·3	0·49	1·57 : 1	0·56	1·67 : 1
Mean ...		0·453	1·518	0·49	1·57 : 1
		Av. dev. $0^m·04$		Av. dev. $0^m·05$	

From hence it appears that the light transmitted by the Refractor of 12¼-in. aperture : that transmitted by the De la Rue Telescope with a 13-in. metallic speculum :: 191 : 100; and in the case of the 13-in. silver-on-glass mirror (by With) 155 : 100.

I will now only quote a concluding remark made by Dr. Robinson in the *Monthly Notices* already cited, to the effect that comparisons such as are here instituted can only be effectually made where the two forms of instruments are set, as it were, side by side: "The comparison can only be fairly made (he truly says) when the conditions are identical; when the locality, the night, the object, the observers are the same; and, I may add, when there is no personal or party bias in the judge." I trust these conditions are well secured in the research detailed in the present communication.

Postscript.—On the reading of the above paper to the Society, a long and interesting discussion took place, in the course of which it became evident that some misapprehension existed as to

the nature and use of the photometer employed. In order, therefore, to remove any doubts as to the exact meaning and scientific character of the measures recorded in the paper, I may observe that the bases of the cones of light proceeding from the stars on to the eye-lenses of the photometers as measured by a dynamometer, in the case of the Grubb instrument, are fairly represented by one-thirtieth of an inch, and in the case of the Reflector (with either mirror) by one-twentieth of an inch: between them and the eye, close to these small luminous circles, the photometer wedges traverse; and furthermore, close to the wedge is placed the eye of the observer, guided and restricted in direction by a small diaphragm with about one-tenth of an inch circular opening. It is certain, therefore, that the whole of the light incident on the object-glass or mirror passes through the wedge and through the pupil to the retina.

I cannot, myself, conceive a more perfect or simple form of a photometer; and, as to the skill with which it is handled, the observations in the text, printed from the note-books of the two able observers, speak to the initiated for themselves.

Since writing the above, I have measured photometrically the ratio of the incidents to the transmitted light of the Grubb 13-in. object glass, and I find the result in very good accordance with that obtained by Dr. Robinson in 1869 for the same object glass by a totally different form of photometer. This and a few similar investigations I propose to make the subject of my next communication to the Society.

Note on a Comparison of the Photometric Magnitudes of the same Stars Observed at Harvard College and at the University Observatory, Oxford. By Prof. C. Pritchard, D.D., F.R.S.

The total number of stars of which the magnitudes have been photometrically measured, both at Harvard College and at Oxford, is up to the present time 1,801.

Of these the number of accordances within one quarter of a magnitude is 1,569; within the tenth of a magnitude the number of accordances is 717.

The number of discordances amounting to a quarter of a magnitude, and less than four-tenths, is 168 out of the 1,800.

The number of discordances amounting to four-tenths of a magnitude and beyond is 64.

Among the probable or possible causes of these discordances, comparatively inconsiderable as they are, may be reckoned:—

1. Errors of observation at one or both Observatories, as shown by the considerable residuals recorded in the Harvard memoir, and by the variable but smaller "average deviations" printed in the Oxford work.
2. The general application of the mean value of the atmospheric absorption on individual nights, whereas this

absorption varies very greatly, and even unexpectedly, with the meteorological conditions of the time and place of the observations.

3. The occasional observations on nights not favourable to accurate measurement.
4. The variability of the lustre of the stars themselves.

It does not appear that either photometer, in its use or construction, is open to systematic error; and further, the effect of small differences of colour does not seem to affect the photometric determination. But there is observable a tendency in the Harvard observations to represent the zenithal magnitudes of stars, at a considerable distance from the zenith, as slightly brighter than the results derived at Oxford. This difference would, to some extent, be explained by supposing the co-efficient of atmospheric absorption, as used at Harvard, to be in excess of its actual amount. The coefficient 0·25 mag. is slightly larger than has been found at Continental observatories, but it is not here suggested that the Harvard value rests on a less secure basis than the others.

Oxford University Observatory:
1884, *Nov.* 13.

Observations of Stars Occulted by the Moon during the Eclipse of October 4, 1884, *at the University Observatory, Oxford.* Made under the direction of Prof. C. Pritchard, D.D., F.R.S.

Phase	Immersion.		Emersion.	
Instrument	Grubb Refractor.	De LaRue Reflector.	Grubb Refractor.	De LaRue Reflector.
Aperture ...	12¼ in.	13 in.	12¼ in.	13 in.
Power ...	120.	150.	120.	150.
Observer ...	Plummer.	Jenkins.	Plummer.	Jenkins.
G.M.T.	h m s	h m s	h m s	h m s
63*			9 31 14·5	9 31 14·3
69			9 39 30·1	9 39 29·8
71			9 19 32·8	
74			9 50 9·0	9 50 8·3
76			9 32 19·0	9 32 19·1
81	9 32 22·7	9 32 23·2	10 36 59	
82	9 23 51·4		10 14 31·7	10 14 33·1†
85	9 23 55·1	9 23 52·3	10 30 52·2	10 30 50·8
94	10 6 34·7	10 6 33·8		
95	10 11 42·1	10 11 43·0		
96		10 39 26·6		
106	10 37 11·0	10 37 12·9		
107		10 37 26·8		
108, 109	10 36 6·4	10 36 6·4‡		

* Numbers as given in Dr. Döllen's list, *Ast. Nach.* No. 2615.
† Star faint. ‡ The immersion of the two stars was simultaneous.

Stars observed as Occulted, but not given in Dr. Döllen's List.

				Estimated Position Angle.
(1)	9 34 1·4			86
(2)			9 37 59·2	160
(3)		9 33 24·2		80
(4)			10 13 47·8	315

Approximate coordinates of the Four Occulted Stars not given in Dr. Döllen's List.

R.A. of (1) = R.A. of	85 + 4′ 14″	Decl. of (1) = Decl. of	85 + 2′ 5″
„ (2) = „	76 + 3 47	„ (2) = „	76 + 0 39
„ (3) = „	85 + 4 31	„ (3) = „	85 + 3 37
„ (4) = „	81 − 7 27	„ (4) = „	81 + 5 9

Owing to the peculiar condition of the occulting limb in respect of illumination, the observations of Immersion were practically more difficult than those of Emersion. The observations of Emersion of stars not predicted may possibly have been affected by unexpectedness of the phenomenon and the greater faintness of the stars.

Altogether 22 phenomena were observed, including the occultation of the four faint stars not predicted in Dr. Döllen's list.

University Observatory, Oxford:
1884, *Nov.* 13.

Total Eclipse of the Moon, 1884, October 4. Observed at the Radcliffe Observatory, Oxford.

(*Communicated by E. J. Stone, M.A., F.R.S.*)

This eclipse was observed at the Radcliffe Observatory, Oxford, with the only two instruments available for the purpose, the Heliometer of 7·5-inches aperture, and the 7-inch Equatorial. Both semi-lenses of the Heliometer were used, but the images were practically coincident. The faint stars occulted before totality were looked for, but none could be observed until the No. 63 of Struve's list. The observations with the Heliometer were made by Mr. Wickham, those with the Equatorial by Mr. Robinson. As there were only two instruments available, I merely watched the eclipse with the naked eye. The eclipse was much the darkest that I have ever seen, and just before the instant of totality it appeared as if the Moon's surface would be invisible to the naked eye during totality; but such was not the case; for with the last appearance of the bright reflected sunlight there appeared a dim circle of light around the Moon's disk, and the whole surface became faintly visible, and continued so until the end of totality.

Occultations of Stars during the Total Eclipse of the Moon of October 4, 1884.

No in Struve's List.	Name of Object.	Phenomenon.	Instrument.	Time Noted. h m s	Time by Sidereal Standard h m s	Local Sidereal Time. h m s	Greenwich Mean Time of Observation. h m s	Observer.	Ref. to Notes
63	Arg. Z. + 4° No. 126	Disappearance	Heliometer	21 54 33·3	21 54 11·90	21 53 33·67	9 2 48·13	W.	
63	"	"	10-foot telescope	21 54 29	21 54 11·50	21 53 33·27	9 2 47·73	R.	(*a*)
71	* 10 Mag.	Disappearance	Heliometer	22 3 25	22 3 3·59	22 2 25·36	9 11 38·37	W.	
85	* 10 Mag.	Disappearance	Heliometer	22 15 38·2	22 15 16·78	22 14 38·55	9 23 49·56	W.	
82	* 10 Mag.	Disappearance	Heliometer	22 16 1·2	22 15 39·78	22 15 1·55	9 24 12·50	W.	
81	Arg. Z. + 4° No. 129	Disappearance	Heliometer	22 25 12·0	22 24 50·57	22 24 12·34	9 33 21·78	W.	(*b*)
81	"	"	10-foot telescope	22 25 7·95	22 24 50·42	22 24 12·19	9 33 21·63	R.	(*c*)
69	Arg. Z. + 3° No. 111	Reappearance	Heliometer	22 31 20·5	22 30 59·06	22 30 20·83	9 39 29·26	W.	
69	"	"	10-foot telescope	22 31 18	22 31 0·46	22 30 22·23	9 39 30·66	R.	(*d*)
74	Arg. Z. + 3° No. 112	Reappearance	Heliometer	22 42 1·3	22 41 39·85	22 41 1·61	9 50 8·30	W.	
74	"	"	10 foot telescope	22 41 56·3	22 41 38·75	22 41 0·51	9 50 7·20	R.	(*e*)
94	* 9–10 Mag.	Disappearance	Heliometer	22 58 30	22 58 8·54	22 57 30·30	10 6 34·29	W.	(*f*)
94	"	"	10-foot telescope	22 58 24·5	22 58 6·94	22 57 28·70	10 6 32·69	R.	(*g*)
95	Arg. Z. + 4° No. 131	Disappearance	Heliometer	23 3 39·2	23 3 17·74	23 2 39·50	10 11 42·64	W.	
95	"	"	10-foot telescope	23 3 35·7	23 3 18·14	23 2 39·90	10 11 43·04	R.	(*h*)
82	* 10 Mag.	Reappearance	Heliometer	23 6 28·0	23 6 6·53	23 5 28·29	10 14 30·97	W.	(*i*)
82	"	"	10-foot telescope	23 6 24·0	23 6 6·43	23 5 28·19	10 14 30·87	R.	(*j*)
85	* 10 Mag.	Reappearance	Heliometer	23 22 49·5	23 22 28·02	23 21 49·78	10 30 49·78	W.	(*k*)
109	Arg. Z. + 4° No. 133	Disappearance	Heliometer	23 28 24·2	23 28 2·71	23 27 24·47	10 36 23·56	W.	
109	"	"	10-foot telescope	23 28 20·0	23 28 2·41	23 27 24·17	10 36 23·26	R.	(*l*)
107	* 9–10 Mag.	Disappearance	Heliometer	23 29 42·2	23 29 20·71	23 28 42·47	10 37 41·35	W.	(*m*)

Notes.

(*a*) Fair observation, but could not secure exact tenth of second. (*b*) Seemed somewhat brighter than 9·5. (*c*) Instantaneous; observation very good. (*d*) May be a second late; was not looking at the exact point of reappearance. (*e*) Instantaneous. Counting ½ sec. fast after occultation (reappearance), but observer picked up correct second before observation. (*f*) "Gradual" disappearance. (*g*) Very fair observation. (*h*) Seemed to enter limb 2ˢ or 3ˢ and then vanished suddenly; time noted satisfactory. (*i*) Good. (*j*) Good; instantaneous. (*k*) Not quite certain; star very faint. (*l*) Good; instantaneous. A faint companion (Struve's List, No. 108) disappeared just before this time. (*m*) Faint.

Power used:—Heliometer 80: 10-foot telescope 109. For Struve's List see *Astronomische Nachrichten*, Band 109. No. 2615.

In converting Oxford Mean Solar Times into Greenwich Mean Solar Times the following Longitude has been used: 5ᵐ 2ˢ·60 W.

Occultations of Stars observed at Dun Echt during the Total Lunar Eclipse of October 4, 1884.

(Communicated by Lord Crawford.)

1. Observations with the Grubb Equatorial of 15·06-ins. aperture, power 122; observer, Ralph Copeland.

No. in the Pulkowa List.	Magnitude.	Phenomenon.	Observed Time by Chronometer.	Dun Echt Mean Time.
			h m s	h m s
94	9–10	Disappearance	10 16 24·5	10 6 41·8
			by Chronograph	
95	9·5	Disappearance	23 5 46·8	10 10 45·3
82	10	Reappearance*	23 9 50·7	10 14 48·5
85	10	„	23 22 9·5	10 27 5·3
81	9·5	„	23 22 59·7	10 27 55·4
109	8·8	Disappearance	23 25 56·4	10 30 51·6
108	9–10	„ †	23 25 57·2 – 0s·5	10 30 51·9
107	10	„ ‡	23 28 23·4	10 33 18·2

The chronometer corr. at $7^h·9760$ by chronom. $= -9^m\ 41^s·73 - 0^s·4158$ per hr.

The chronograph corr. at $22^h\ 35^m·3$ by chronog. $= +\ 59^s·34 + 0^s·0822$ „

State of Weather and General Remarks.

Although there were only a few cumulus clouds scattered over the heavens, and the sky in general was fairly clear, the illuminated haze around the Moon was too bright to permit of stars 57, 62, 69, and 71 of the Pulkowa list being seen at all, even in the 15-in. telescope. No. 74, of the 9·3 magnitude, was, in fact, the first star made out, and that only with extreme difficulty, shortly before its disappearance, which took place

Notes.

* 82 reappeared suddenly.

† (108) Signal given half a second too late; the disappearance followed so closely on that of 109, that the key could not be pressed early enough for the second record.

‡ (107) The Moon's limb was of a bright primrose colour, and the star appeared to cling to the edge for several seconds before disappearing.

By the time ($10^h\ 16^m·6$ G.M.T) when 94 ought to have reappeared, the sky had become quite white through illumination by the uneclipsed part of the Moon, and the limb was not visible for more than 3′, or at most 4′ from the northern cusp. The 9^m star, 106*a*, the place of which is given below, was seen at $11^h\ 21^m$ G.M.T., about two minutes after egress, and its reappearance might have been observed if attention could have been directed to the *exact* place of emergence. On the other hand, the $8^m·8$ star 109, which was predicted to reappear at $11^h\ 49^m\ 50^s$ G.M.T., although caught sight of about 30^s later, was then so very faint that its egress could not have been observed with more certainty than that of a comparatively small star at the Moon's bright limb under ordinary conditions. Its 9–10 mag. companion, 108, was indistinguishable in the glare, and within about another minute the star itself had disappeared in the increasing light of the emerging Moon.

about $9^h\ 3^m\ 52^s$ G.M.T., or 15^s later than predicted; but the observation is altogether too uncertain to be of any use beyond showing that the star was actually seen. After this for a time the clouds were very troublesome, the only record being to the effect that a momentary glimpse of the Moon's eclipsed limb was obtained at $9^h\ 17^m$. About 10^h G.M.T. a sudden change for the better took place, and at $10^h\ 1^m\ 45^s$ the group of stars 69, 71, 74, 76, and 76*a*,* the last certainly not brighter than the 11th magnitude, and not in the Pulkowa list, were beautifully seen in a splendid black sky through a momentary rift in the clouds, the star 74 which had just emerged being only some 30″ from the Moon's limb. Unfortunately there were no occultations for the next quarter of an hour, but those that came subsequently were observed with great certainty until about $10^h\ 43^m$ G.M.T., when the rapid brightening of the Moon as it approached the margin of the shadow began again to cast difficulties in the way. By 10 or 12 minutes after the end of the total phase, or by 11^h G.M.T., the special facilities of the occasion may be said, in a great measure, to have passed away, although from what was seen of stars 106*a* and 109 it seems that the egresses of 8 or 8½ magnitude stars might have been observed at the Moon's obscured limb until the end of the actual *umbral* eclipse, and conversely the disappearances of such stars might have been perceptible at the commencement of that phase. The record at $10^h\ 2^m$ shows that near the middle of a total lunar eclipse stars of the 11th magnitude may be advantageously placed on an occultation list.

When the Moon was visible the corresponding places of the stars on her limb were readily found by simply setting the telescope in declination, which can be quickly done from the eye-end of the instrument. At other times use had to be made of the configurations of neighbouring stars, as shown in the map.

2. Observations made with the 6·06-in. Simms' Equatorial, power 91, by Mr. J. G. Lohse.

As a preparation the 16 stars for which the predicted times of disappearance and reappearance had been sent from Pulkowa by M. Struve were mapped on a large scale on millimetre paper, together with the apparent path of the Moon, the necessary data having also been supplied from Russia. A comparison with Chacornac's map made it probable that two additional stars might be occulted, so on the next clear night these, as well as a few other stars that were to serve as guides for the reappearances, were connected micrometrically with the nearest star of the Pulkowa list. The phenomena were numbered 1 to 36, and the order in which the stars disappeared and reappeared indi-

* (76*a*) $\alpha - 11^\circ\ 12'\!\cdot\!5,\ \delta = +3^\circ\ 51'\!\cdot\!8.$

cated on the map by writing the number of the disappearance below and that of the reappearance above each star. No use was made of the position angles for the reappearances, for it was to be expected that the Moon's light would not be sufficient to make the wires visible, and a constant artificial illumination would have been very objectionable. The known differences of declination between the stars, however, made it very easy by a series of simple operations to bring the spot where the reappearance was to be looked for into the centre of the field. Having selected for every star a conveniently situated reference star, and ascertained beforehand the readings of the micrometer screws corresponding to the difference of declination of these two stars, it remained to set the micrometer, illuminate the wires, bring the reference star on to its wire by the slow motion in declination, centre the other wire by means of the slipping-piece, remove the illumination, and turn the telescope by the slow motion in Right Ascension, until the edge of the Moon was in the centre of the field. Should the Moon not have been visible, the map would have permitted an estimate of the distance from the reference star.

Before the total phase the Moon was several times well seen between clouds, but not a trace of the stars could be made out. Gradually the clouds thickened, and hid the Moon for the first half of the total phase. The sky then began to clear up and eventually became perfectly cloudless.

During the totality the moon was very faint, and the copper tint, so conspicuous in other eclipses, was only seen occasionally, and then only feebly, and not uniformly spread over the Moon, but more intense in some parts than in others.

The following are the observations obtained during the latter half of the totality. The times were chronographed, as were also the observations for time. The places of the fundamental stars were taken from the *Berliner Jahrbuch.* Of the signals, three were noted as having been sent too late by about one second, the corresponding times have therefore been lessened by that quantity.

No. in the Pulkowa List.	Magnitude.	Phenomenon.	Observed Time by Chronograph.	Dun Echt Mean Time.
			h m s s	h m s
94	9–10	Disappearance	23 1 44·2 ± 1	10 6 43·4
95	9·5	„	5 48·75 − 1	10 46·2
82	10	Reappearance	9 50·0	14 47·8
—	—	„	[10 10·1 − 1]	
85	10	„	22 18·0 − 1	27 12·8
81	9·5	„	22 59·35	27 55·0
109	8·8	Disappearance	25 56·55	30 51·8
Anon.	9	„	26 32·7	31 27·8

The corrections for the chronograph are the same as before.

Notes.

(94) Very difficult; uncertain to about ± 1ˢ.

(95) Very difficult; about 1ˢ late.

(82) This star reappeared suddenly, and was duly chronographed at $23^h\ 9^m\ 50^s{\cdot}0$, but it was hidden so quickly afterwards by clouds, as to leave a doubt of its having been seen. On its again becoming visible 20ˢ later, a second signal was given. There seems little doubt that the earlier record marks the actual reappearance.

(85) Observation fairly good, but sent the signal 1ˢ too late.

(81) Fairly good.

(109) Good. No. 108 was too faint to attempt an accurate observation; it disappeared almost immediately after 109.

Anon. (106*a*). Observation good. The approximate place from a single observation is

$$\alpha = 11^\circ\ 49'{\cdot}8,\ \delta = +4^\circ\ 7'{\cdot}6.$$

No. 107 was missed, and at the time of the disappearance of 106 the field of view was so strongly lit up by the partly illuminated Moon, that neither this star nor any of the others that had already reappeared could be seen.

Lord Crawford's Observatory,
Dun Echt:
1884. *Nov.* 13.

Total Eclipse of Moon, Oct. 4, 1884. By the Rev. S. J. Perry, F.R.S.

This eclipse was observed at Stonyhurst under very favourable circumstances, although the heavy dew interfered occasionally with the definition of the telescopes.

With a good binocular the Moon's disk was easily seen throughout the whole of totality, but to the naked eye there was no outline, the Moon having the appearance of a bright patch of light. The usual copper tint of the eclipsed Moon was not perceived except towards the close of the eclipse, and then it was only very slight. The general appearance in the binocular was that of a dull white ball, rather more brilliant at one part of the surface than elsewhere. The telescopes used were two Equatorials of 8 and 4 inches, a 9½-inch Cassegrain, and a 7-inch Newtonian. The nature of the phenomena does not appear to admit of any great accuracy in the contacts.

Observations.	G.M.T.	Observer.	Instr.	Remarks.
	h m s			
First contact with shadow	8 15 20·4	S. P.	8-in.	Def. poor.
,,	8 16 31·0	J. R.	Cassegrain	,,
Beginning of totality	9 18 52	A. M.	4-in.	
,,	9 19 30·8	J. R.	Cassegrain.	
End of totality	10 46 6·3	,,	,,	A little late.
,,	10 46 31·5	S. P.	Binocular.	Fair.
Last contact with shadow	11 48 45·9	J. R.	Cassegrain.	
,,	11 48 52·1	A. C.	Newtonian.	
,,	11 49 54·2	S. P.	Binocular	Limb still charred.

The following stars were occulted :—

Döllen's No.	G.M.T. Disappearance.	G.M.T. Reappearance.	Observer.	Instr.	Remarks.
	h m s	h m s			
81	9 36 41·6	10 35 4·5	W. C.	8-in.	
81	9 36 53·2		A. M.	4-in.	Fair.
82	9 22 36·0		W. C.	8	Some uncertainty as to star.
85	9 24 23·8	10 31 38·5	W. C.	8	Good.
94	10 8 44·6		S. P.	8	
95	10 13 27·2		S. P.	8	
106	10 43 35·9		J. R.	Cassegrain.	
106	10 43 35·9		A. C.	4	Difficult.
109	10 36 50·2		J. R.		
109	10 36 57·2		A. C.		Poor.
Unknown.	9 35 6·3		W. C.		45° 10′ from N.

The initials stand for A. Müller, A. Cortie, W. Carlisle, J. Rooney, and S. Perry.

Stonyhurst Observatory:
1884, *Nov.* 8.

Occultations Observed during the Total Eclipse of the Moon, 1884, *October* 4, *at Harrow.* By Lieut.-Col. G. L. Tupman.

I used the 4½-inch Cooke Refractor which is fitted with position-circle and bar eyepiece, power 66, extremely convenient for occultations. Scarcely any of the stars on M. Döllen's list could be seen before the Moon was totally immersed, and, even during the period of the greatest obscuration, stars of about the tenth magnitude became extremely faint when within a second of arc of the Moon's limb, owing to the brightness of the latter. The

sky was quite clear and the air steady. An assistant called the seconds aloud from the mean-time chronometer Fletcher 1050. For the reappearances the bar was set to the position-angle and placed tangent to the Moon's limb a few seconds of arc off the limb. In spite of this precaution several reappearances were observed for which I could not be certain that I caught the exact emersion. The following are the only times for which I was sure of the phase:—

Star.	Green. M.T. h m s	Phase.
63	9 2 7·0	Disap.
81	9 33 40·6	"
69	9 39 35·1	Reap.
74	9 50 14·1	"
94	10 6 54·1	Disap.
109	10 37 25·6	"

The time was determined, with a small transit instrument lent to me by Mr. Latimer Clark, by observing high and low stars with reversed positions of the axis.

1884.	G.M.T. h m	Fletcher 1050 fast on G.M.T. s	
Sept. 30	9 57	27·3	1 star only
Oct. 3	9 38	23·76	8 stars
11	9 53	9·07	4 "

In the middle of the eclipse the chronometric correction has been taken $-22^s{\cdot}4$. The Greenwich mean time has been obtained by allowing the Geodetic Longitude $1^m\ 20^s{\cdot}0$ West, taken from the 6-inch ordnance survey.

The total light reflected from the Moon was compared directly with the stars as follows:—

	h m		
At	9 45	G.M.T. equal to	2½ magnitude.
	10 8	"	3 "
	10 30	"	2 "
	10 44	"	Capella

The very slight ruddy tint during totality was not perceptible until a direct comparison with white stars was made.

The Total Eclipse of the Moon, 1884, *October* 4. By W. F. Denning.

A perfectly cloudless sky enabled the total lunar eclipse of October 4 to be well observed from this city.

The most noteworthy feature in connection with the phenomenon was that the Moon, at the total phase, appeared far less

luminous than usual. During the preceding eclipses of 1870, July 12, 1877, February 27 and August 23, all of which I observed, our satellite seemed considerably brighter than on the present occasion, and the colouring was more striking. The remarkable opacity of the shadow became evident when it had well encroached upon the Moon's eastern limb, and the fact was fully confirmed by the aspect of her disc during the subsequent stages of the eclipse.

The firmament grew as dark as on an ordinary night when the moon is entirely absent, and but for the indistinct outline of our satellite projected upon the dark background of the sky, there was nothing abnormal in the appearance of the heavens. Small stars could be distinguished with the customary readiness, and the Moon herself, high in the southern sky, looked like a large, ill-defined nebula with indeterminate outlines, or like a planet struggling feebly through very thick haze. Applying my 10-in. Reflector, power 60, her sharply circular contour, however, still admitted of satisfactory observation, and many leading features of the surface were recognised amid the prevailing gloom in which her landscape was involved.

As the Moon emerged from the umbra I believe the depth of the shading was perceptibly less intense than during the immersion. The blue tint so often observed in previous eclipses was distinctly present near the borders of the shadow, while in the more interior region the colouring developed into a dark reddish-brown; but the effect of the different hues and their variations during the progress of this eclipse were far less notable (owing to the extreme darkness of the umbra) than during the similar phenomena of 1870 and 1877 as I remember them.

I took advantage of the dark sky during the Moon's obscuration to examine the comet discovered by Wolf at Heidelberg on September 17. Its position was some 12° E. of the cluster of bright stars in the head of *Delphinus*; the comet was seen as a round nebulosity about 3′ diameter, and with a bright stellar nucleus.

Bristol:
1884, *Oct.* 8.

Abnormal Obscurity of the Moon in the late Eclipse. By the Rev. S. J. Johnson, M.A.

On the evening of October 4 there was a conspicuous return of the sunset after-glow that was common last winter. A peculiar state of the strata of our atmosphere might, therefore, indicate that something unusual was to be expected in the eclipse following.

At 8^h, penumbra barely perceptible with opera-glass.

At $8^h\ 12^m$, very decided.

$8^h\ 18^m\ 5^s$, shadow had reached *Grimaldi.*

At $9^h\ 7^m$, for the first time, a very small portion of the eclipsed disk, extending only 4′ or 5′ inwards, could be discerned through the telescope, this appearing of a dark slate colour—the same tint as is usually observed at the commencement of an eclipse.

At $9^h\ 10^m$, the whole of the lunar circle began to be seen through the telescope, but without a trace of the ordinary coppery redness.

$9^h\ 29^m\ 7^s$, reappearance of small star (time by sextant).

$10^h\ 2^m$, middle of totality. To the naked eye nothing could be seen but a faint nebulous spot. That the obscurity of the Moon arose from lack of illumination, not from fog or cloud, was seen by the fact that stars of small magnitudes above and below the lunar disk shone as distinctly as on an ordinary dark night. The exact appearance of the Moon at this time would be described by quoting Kepler's words verbatim about the eclipse of June (not December) 1620. "Luna difficillimè apparuit, emicuit tamen instar tenuissimæ nubeculæ, longè debilior quam viâ lacteâ, sine omni rubedine."

$10^h\ 8^m\ 21^s$, immersion of very faint star. Uncertain to 3 or 4 seconds.

$10^h\ 33^m\ 41^s$, star of magnitude $8\frac{1}{2}$ occulted. Appeared to linger for 4 seconds within the Moon's limb.

$10^h\ 39^m\ 28^s$, reappearance of a star.

$10^h\ 49^m\ 15^s$, sunlight breaking out.

The shadow left the Moon near the *Mare Fœcunditatis* about $11.48\frac{3}{4}$, the penumbra being conspicuous to the naked eye at 11 51. Thus, while the Moon did not completely disappear during totality (except to one correspondent), the peculiar features of the eclipse were the complete invisibility of the eclipsed orb until nine-tenths were covered, also subsequent to the total phase after one-tenth was uncovered. In this respect it seems similar to the earliest instance of the kind given in modern times, that observed by Kepler in 1601, an eclipse of nine-tenths of the Moon's disk. His words are (*Astronomiæ pars optica*), "Anno 1601 Decembri, tenuissimo cornu superstite, caliginosam tamen partem non vidi."

The usual explanation, that when the atmosphere is remarkably free from vapour the red rays would be absorbed, is hardly an adequate one.

(1.) Because the atmosphere was in an equal state of dryness on the occasion of the eclipse of July 12, 1870, when the Moon assumed the usual dull red or copper colour.

(2.) Because the last instance of the disappearance of the Moon was on June 10, 1816, when it could not be discerned even with telescopes, and this was one of the wettest summers in the century.

Melplash Vicarage,
Bridport : Oct. 11.

Observations of Comet 1884 (Barnard) made at the Royal Observatory, Cape of Good Hope.

(Communicated by David Gill, LL.D., F.R.S., H.M. Astronomer.)

The following observations were made with the 7-inch Equatorial and Repsold filar micrometer by Mr. W. H. Finlay, Chief Assistant. The comet was so situated that meridian observations of the comparison stars could always be secured with the transit circle within a few nights after their comparison with the comet. The observations are corrected for the effects of refraction.

The comet throughout presented the appearance of a small diffused nebulous mass. A nucleus was seen by glimpses on July 28, but the bright moonlight on following nights prevented more than an occasional suspicion of its existence. About the end of July the point of greatest condensation (in which the nucleus had been seen) was slightly towards the following part of the mass; this was the point observed. In August the appearance of the comet was reduced by moonlight to a small round mass slightly brighter towards the centre; the centre of this mass was observed. The comet presented a similar appearance in September, and was similarly observed. The comet, as a rule, was faint and difficult to observe in August, probably from its being projected on the Milky Way as a background. An apparent increase of brightness on September 15 and following days was very striking, compared with the appearance of the comet in the end of August.

Observations of Comet Pons-Brooks have been secured on forty-three nights from January 16 to April 29 inclusive, and will be published so soon as the meridian observations of the comparison stars have been completed.

Differences of R.A. and N.P.D. of the Comet and Comparison Stars, observed with the 7-inch Equatorial.

Date.		Cape Mean Time.	Δα ☌ − ✱	No. of Trans.	Δ N.P.D. ☌ − ✱	No. of Bisecs.	Comparison ✱
		h m s	m s		′ ″		
July	24	10 8 8·1	−0 13·0	4	+6 57·1	4	*a*
	26	10 38 4·0	+4 30·38	4	−6 29·0	4	*b*
	27	10 54 54·1	+0 10·09	16	−1 14·3	16	*c*
	28	11 6 15·8	−0 14·11	16	+6 33·3	16	Stone 8897.
	29	11 10 32·2	+1 0·99	16	−2 26·8	16	Stone 8913.
	30	11 5 15·7	+0 47·41	16	+1 59·5	16	*d*
Aug.	1	10 19 53·3	−0 7·04	10	+1 31·0	6	*e*
	5	9 35 49·5	+0 32·05	16	+0 53·5	16	*f*
	6	9 53 49·7	+0 30·12	16	+2 18·8	16	*g*
	7	10 10 18·4	+0 21·60	16	+1 31·6	16	*h*
	8	10 10 5·0	−0 20·07	20	−0 46·7	16	*i*

Date.	Cape Mean Time.	Δα ☌ − ✱	No. of Trans.	Δ N.P.D. ☌ − ✱	No. of Bisecs.	Comparison ✱
	h m s	m s		′ ″		
Aug. 11	10 4 50·4	−0 22·80	20	−1 2·6	16	*k*
13	10 14 35·2	+0 23·13	20	−3 30·7	16	*l*
14	9 45 9·5	−0 21·98	12	−3 17·2	12	*m*
17	9 47 36·8	+0 29·46	16	+0 0·8	16	*n*
19	10 10 4·8	−0 17·79	15	−2 37·2	16	*o*
20	10 2 33·1			−0 9·5	8	*p*
20	10 12 46·7	−0 25·26	16			*p*
22	10 26 1·8	+0 10·08	16	+4 52·3	16	*q*
23	10 4 39·6	+0 35·86	16	+5 4·2	16	Yarnall 7433.
Sept. 15	10 19 31·8	+0 11·50	24	+5 7·9	18	O. Arg. S. 19534.
17	10 27 13·5	−0 51·09	16	+2 12·9	16	O. Arg. S. 19737.
21	9 44 44·1	−0 16·20	17	−2 26·6	12	Stone 10673.
22	10 12 12·9	+0 54·93	12	+0 7·3	16	O. Arg. S. 20039.

Notes.

July 24. Comet exceedingly faint and difficult; hazy.
28. Comet much easier to-night; distinct appearance of nucleus or condensation.
Aug. 1. Comet very faint: bright moonlight.
5. Moon very bright; but fair observations.
7. Bright moonlight; air very damp and hazy; comet very faint.
13. Comet faint.
19. Comet very faint; very difficult.
20. Comet exceedingly faint, scarcely possible to observe at all.
22. Fair observations.
Sept. 15. Comet much easier, and brighter than when last observed.

The following Table gives the differences of Right Ascension and N.P.D. between the comparison stars and brighter stars observed with the Equatorial.

Star.	Mag.	R.A. = ✱	N.P.D. = ✱	Compared with ✱.
		m s	′ ″	
a	9½	+2 5·10	−1 30·8	*a′*
b	9	−4 22·0	−5 49·5	*b′*
c	10	−2 57·55	+7 51·9	Stone 8897.
c	10	−4 19·75	−0 52·0	Stone 8913.
d	7½	+2 55·0	−4 54·6	Stone 8913.
e	10	+0 13·10	+3 43·1	*e′*
f	10	+2 32·85	−0 45·7	Stone 9061.
h	9½	+3 28·30	−1 55·0	*g*
h	9½	−4 2·95	+0 35·5	*i*
k	10	+0 15·12	−7 10·2	*k′*
k′	8½	+0 3·10	−7 40·7	Stone 9295.
o	10½	−0 26·90	−2 33·5	*o′*

Adopted Right Ascensions and North Polar distances of Stars observed with the Comet.

Star.	Mag.	Mean R.A. 1884·0.	Mean N.P.D. 1884·0.	Date of Comp. with ☌	Reductions to App. Place. R.A.	Reductions to App. Place. N.P.D.	Authority for Mean Place.
		h m s	° ′ ″		s	″	
a	9½	16 5 39·80	127 7 47·3	July 24	+3·83	+ 5·7	Measures with Equatorial.
a′	8½	16 3 34·70	127 9 18·1	24	+3·83	+ 5·7	3 Meridian observations Cape 1884
b	9	16 5 40 52	127 21 57 9	26	+3·85	+ 5·2	Measures with Equatorial.
b′	7½	16 10 2·52	127 27 47·4	26	+3·85	+ 5·2	3 Meridian observations.
c	10	16 12 27·70	127 16 44·8	27	+3·84	+ 5·0	Measures with Equatorial.
Stone 8897	7	16 15 24·88	127 8 52·4	27, 28	+3·84	+ 4·7	Stone 8897.
Stone 8913	6	16 16 47·64	127 17 37·2	27, 29	+3·82	+ 4·7	Stone 8913.
d	7½	16 19 42·64	127 12 42·6	30	+3·82	+ 4·7	Measures with Equatorial.
e	10	16 26 8·91	127 11 44·7	Aug. 1	+3·84	+ 3·8	„ „
e′	8	16 25 55·81	127 8 1·6	1	+3·84	+ 3·8	2 Meridian observations.
Stone 9061	7	16 34 59·59	127 6 55·4	5	+3·83	+ 3·0	Stone 9061.
f	10	16 37 32·44	127 6 9·7	5	+3·83	+ 3·0	Measures with Equatorial.
g	7½	16 40 50·42	127 2 23·1	6	+3·84	+ 2·5	2 Meridian observations.
h	9½	16 44 18·34	127 0 29·3	7	+3·84	+ 2·1	Measures with Equatorial.
i	7½	16 48 20·93	126 59 54·7	8	+3·85	+ 1·8	3 Meridian observations.

Star.	Mag.	Mean R.A. 1884·0.	Mean N.P.D. 1884·0.	Date of Comp. with ☌	Reductions to App. Place. R.A.	Reductions to App. Place. N.P.D.	Authority for Mean Place.
		h m s	° ′ ″		s	″	
Stone 9295	6½	16 58 30·01	127 3 58·2	Aug. 11	+ 3·86	+ 0·9	Stone 9295.
k′	8½	16 58 33·17	126 56 17·1	11	+ 3·86	+ 0·9	2 Meridian observations.
k	10	16 58 48·29	126 49 6·9	11	+ 3·86	+ 0·9	Measures with Equatorial.
l	9½	17 5 18·69	126 42 15·1	13	+ 3·85	+ 0·2	2 Meridian observations.
m	9	17 9 41·92	126 36 43·1	14	+ 3·85	− 0·2	3 „
n	9½	17 20 14·28	126 14 55·0	17	+ 3·84	− 1·2	2 „
o	10½	17 28 54·91	126 2 44·1	19	+ 3·84	− 2·1	Measures with Equatorial.
o′	8½	17 29 21·81	126 5 17·6	19	+ 3·84	− 2·1	2 Meridian observations.
p	9	17 33 1·39	125 52 26·2	20	+ 3·83	− 2·4	2 „
q	8	17 40 30·55	125 29 35·7	22	+ 3·82	− 3·2	2 „
Yarnall 7433	8½	17 44 5·16	125 19 53·4	23	+ 3·81	− 3·5	Cape and Washington.
O. Arg. S. 19534	8½	19 19 48·86	119 32 10·0	Sept. 15	+ 3·59	− 12·2	O. Arg. and 2 Cape Merid. observs.
„ 19737*	8½	19 28 48·23	118 55 17·6	17	+ 3·57	− 13·0	2 Meridian observations.
„ 19997	8½	19 43 37·70	117 38 28·8	21	+ 3·52	− 14·2	Stone 10673.
„ 20039	7½	19 46 17·93	117 14 26·5	23	+ 3·50	− 14·4	O. Arg., Wash., 8540 & Cape Mer.

Resulting Places of the Comet.

Date.	Cape M.T.	R.A.	Log. par. factor.	N.P.D.	Log. par factor.
	h m s	h m s		° ′ ″	
July 24	10 8 8·1	16 5 30·56	8·6170	127 14 49·1	8·5798
26	10 38 4·0	16 10 14·75	8·6675	127 15 34·1	8·8389
27	10 54 54·1	16 12 41·63	8·7033	127 15 35·5	8·9868
28	11 6 15·8	16 15 14·61	8·7251	127 15 30·4	9·0719
29	11 10 32·2	16 17 52·45	8·7340	127 15 15·1	9·1072
30	11 5 15·7	16 20 33·87	8·7267	127 14 46·8	9·0792
Aug. 1	10 19 53·3	16 26 5·69	8·6435	127 13 19·6	8·5911
5	9 35 49·5	16 38 8·32	8·5302	127 7 6·2	7·6990
6	9 53 49·7	16 41 24·38	8·5798	127 4 44·4	8·4472
7	10 10 18·4	16 44 43·78	8·6325	127 2 3·0	8·7076
8	10 10 5·0	16 48 4·67	8·6325	126 59 9·8	8·7076
11	10 4 50·4	16 58 29·35	8·6222	126 48 5·2	8·6902
13	10 14 35·2	17 5 45·67	8·6464	126 38 44·6	8·8195
14	9 45 9·5	17 9 23·79	8·5798	126 33 25·7	8·5315
17	9 47 36·8	17 20 47·58	8·5763	126 14 54·6	8·5798
19	10 10 4·8	17 28 40·96	8·6345	126 0 4·9	8·8325
20	10 12 46·7	17 32 39·96	8·6395	125 52 10·9	8·7709
22	10 26 1·8	17 40 44·45	8·6665	125 34 24·9	9·0000
23	10 4 39·6	17 44 44·83	8·6170	125 24 54·1	8·8513
Sept. 15	10 19 31·8	19 20 3·95	8·6138	119 37 5·7	9·2355
17	10 27 13·5	19 28 0·71	8·6263	118 57 17·5	9·2718
21	9 44 44·1	19 43 25·02	8·5132	117 35 48·0	9·2253
22	10 12 12·9	19 47 16·36	8·5866	117 14 19·4	9·2945

The comet was also observed with the transit-circle by Mr. Finlay on August 14 and 16, with the following results:—

Aug. 14	7 34 48·8	17 9 6·19		126 33 57·5	8·6812
16	7 34 26·0	17 16 36·39		126 22 6·6	8·6435

The Orbit of Barnard's Comet, 1884. By J. Morrison, M.D., Ph.D., Assistant on the American Ephemeris, Washington, D.C.

From the numerous observations of this comet, already published, I select for the purpose of computing elliptic elements the following observations made at Cambridge, Mass., Nice, and Washington respectively:—

Washington M.T.	α	δ
	° ′ ″	° ′ ″
July 25·371990	242 4 4·5	−37 15 32·0
Aug. 24·124442	267 10 42·3	−35 15 30·4
Sept. 23·339919	297 55 9·3	−26 49 50·6

From these positions I obtain by the usual methods the following system of elliptic elements :—

Epoch	1884, Sept. 24·5 Wash. M.T.	
M	7° 13′ 19″·52	Mean Equinox of 1884·0.
ω	300 57 44·43	
☊	5 11 23·56	
i	5 27 18·94	
ϕ	35 37 2·50	
log q	0·1069968	
log a	0·4862043	
log μ	2·8207001	
P	1958·41 days.	

The residuals for the middle place are zero, and for the following dates the difference between the computed and observed places is as small as can be expected, considering the great difficulty in observing accurately so faint an object :—

Wash. M.T.	C−O. $d\lambda \cos\beta$.	C−O. $d\beta$.	log. Δ.
	″	″	
1884, Aug. 12·361652	+ 6·52	− 3·21	9·65375
Sept. 15·408454	+ 9·85	− 8·09	9·74018
Oct. 11·318804	+ 30·91	− 10·62	9·86241
14·365442	+ 21·56	+ 15·71	9·87849

Observations of Comet Barnard, 1884. By John Tebbutt.

The telegram announcing this comet was received from the Melbourne Observatory on July 23, and the comet itself was found on the following evening. Throughout the whole period of observation the comet was excessively faint, and on August 22 was seen with the greatest difficulty. I have made the accompanying observations with the square bar-micrometer on the 4½-in. Equatorial, the whole series being carefully corrected for defective orientation of the micrometer and for proper motion. The refraction corrections, owing to the great altitude at which the comet was observed, are insensible. In those cases where the comparison stars were found in Stone's *Cape Catalogue*, the precessions and secular variations of that catalogue were employed in bringing up the star's mean places to 1884·0. In all other cases the precessions have been calculated for the mean epochs by means of Peter's elements.

Apparent Places of Comet Barnard, 1884.

Windsor M. T.	R.A.	Log $\frac{p}{P}$.	N.P.D.	Log $\frac{q}{P}$	No. of Comps.	Comp. Star.
d h m s	h m s		° ′ ″			
July 24 9 38 34	16 4 41·06	+8·4868	127 14 23·7	−8·1770	4	1
24 9 38 34	16 4 41·10	+8·4868	127 14 26·3	−8·1770	4	2
27 14 24 36	16 12 9·41	+8·8388	127 15 21·3	+9·7125	3	3
27 14 24 36	16 12 8·99	+8·8388	127 15 18·8	+9·7125	3	4
28 9 13 27	16 14 6·42	+8·4054	127 15 36·5	−8·5057	10	4
28 10 40 7	16 14 15·43	+8·6782	127 15 25·2	+8·8403	5	3
28 10 40 7	16 14 15·43	+8·6782	127 15 27·4	+8·8403	5	4
31 9 41 34	16 22 9·77	+8·5342	127 14 24·5	−7·2041	7	3
31 9 41 34	16 22 9·67	+8·5342	127 14 25·8	−7·2041	7	4
31 9 41 34	16 22 9·03	+8·5342			7	5
31 9 41 34	16 22 9·51	+8·5342	127 14 24·9	−7·2041	7	6
Aug. 2 9 8 57	* +2 2·83	+8·4123	* +12 42·3	−8·4768	6	7
2 9 8 57	* +1 49·13	+8·4123	* + 4 27·5	−8·4768	6	8
2 9 8 57	* −1 24·31	+8·4123	* +18 23·8	−8·4768	6	9
2 9 8 57	16 27 48·54	+8·4123	127 12 34·0	−8·4768	6	10
2 9 8 57	16 27 48·29	+8·4123	127 12 34·5	−8·4768	6	11
4 8 40 9	* +4 33·37	+8·2563	* + 15 37·8	−8·6801	3	9
4 8 40 9	16 33 46·12	+8·2563	127 9 48·9	−8·6801	3	10
6 10 26 23	16 40 16·59	+8·6683	127 5 37·4	+8·8140	7	10
6 10 26 23	16 40 16·87	+8·6683	127 5 35·4	+8·8140	7	12
6 10 26 23	* −0 37·33	+8·6683	* + 3 10·1	+8·8140	7	13
6 10 26 23	16 40 16·78	+8·6683	127 5 34·3	+8·8140	7	14
8 9 29 56	* +5 50·56	+8·5167	* − 2 6·6	−7·4478	10	13
8 9 29 56	16 46 44·46	+8·5167	127 0 17·0	−7·4478	10	14
8 9 29 56	16 46 44·35	+8·5167	127 0 21·0	−7·4478	10	15
9 9 13 4	16 50 5·63	+8·4532	126 57 8·6	−8·2477	7	16
9 9 13 4	16 50 5·23	+8·4532	126 57 8·5	−8·2477	7	17
10 8 26 9	16 53 25·60	+8·1767	126 53 51·8	−8·6862	2	16
10 8 26 9	16 53 25·28	+8·1767	126 53 52·6	−8·6862	2	17
11 8 34 13	16 56 57·63	+8·2434	126 50 0·6	−8·6347	2	17
11 9 15 13	16 57 3·82	+8·4652	126 49 39·0	−8·1093	12	16
12 8 41 31	17 0 33·76	+8·2951	126 45 40·2	−8·5730	6	16
13 9 36 37	17 4 18·66	+8·5447	126 40 35·4	+8·0738	6	17
14 8 56 17	17 7 54·60	+8·3817	126 35 43·2	−8·3816	4	18
14 9 5 13	17 7 55·56	+8·4248	126 35 38·5	−8·2294	3	19
16 10 4 27	17 15 35·12	+8·6236	126 23 42·0	+8·7040	10	19
16 10 4 27	17 15 35·37	+8·6236	126 23 42·2	+8·7040	10	18
18 9 6 0	17 23 8·18	+8·4286	126 10 38·5	−7·9525	10	19
22 10 6 32	17 39 12·28	+8·6246	125 37 39·3	+8·8118	12	20
22 10 6 32	17 39 12·01	+8·6246	125 37 41·4	+8·8118	12	21

Adopted Mean Places of the Comparison Stars for 1884·0, with the Reductions to the Apparent Places for the Dates of Observation.

Star.	R.A.	Reduction.	N.P.D.	Reduction.	Authorities.
	h m s	"	° ′ ″	"	
1	15 56 57·72	+3·80	127 32 16·4	+ 6·5	Wash. Mural Cir. Zone 24, 16; Wash. Cat. 1860, 6623; Cape Cat. 1880, 8727.
2	15 57 2·14	+3·80	127 29 40·9	+ 6·4	Wash. Mural Cir. Zone 24, 17; Wash. Cat. 1860, 6624; Cape Cat. 1880, 8730.
3	16 10 2·58	+3·84	127 27 45·1	+ 5·2	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47·65	+3·87	127 17 36·8	+ 4·5	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
4	16 16 47·65	+3·86	127 17 36·8	+ 4·6	Ditto. ditto.
3	16 10 2·58	+3·83	127 27 45·1	+ 5·3	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47·65	+3·86	127 17 36·8	+ 4·6	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
3	16 10 2·58	+3·78	127 27 45·1	+ 5·4	Wash. Mural Cir. Zone, 24, 18.
4	16 16 47·65	+3·81	127 17 36·8	+ 4·7	Wash. Mural Cir. Zone 24, 19; Wash. Cat. 1860, 6768; Cape Cat. 1880, 8913.
5	16 15 24·88	+3·80			Cape Cat. 1880, 8897.
6	16 19 42·39	+3·83	127 12 39·2	+ 4·4	Anonymous = 9 mag. Equatorial comparisons.
7	16 25 41·9	+3·82	126 59 49	+ 3·8	„ = 8 mag. „ „
8	16 25 55·9	+3·83	127 8 3	− 3·8	„ = 7½ mag. „ „
9	16 29 8·8	+3·84	126 54 8	+ 3·4	„ = 8½ mag. „ „
10	16 31 19·43	+3·86	126 58 56·7	+ 3·2	Wash. Cat. 1860, 6851; Cape Cat. 1880, 9019.
11	16 33 0·68	+3·86	126 55 27·7	+ 3·0	„ 1860, 6864; „ 1880, 9046.
9	16 29 8·8	+3·81	126 54 8	+ 3·5	Anonymous = 8½ mag. Equatorial comparisons.
10	16 31 19·43	+3·83	126 58 56·7	+ 3·3	Wash. Cat. 1860, 6851; Cape Cat. 1880, 9019.
10	16 31 19·43	+3·79	126 58 56·7	+ 3·3	Ditto. ditto.
12	16 34 59·59	+3·82	127 6 55·4	+ 3·0	Cape Cat. 1880, 9061.

Star.	R.A.	Reduction.	N.P.D.	Reduction.	Authorities.
	h m s	s	° ′ ″	″	
13	16 40 50·2	+3·85	127 2 24	+ 2·4	Anonymous = 8 mag. Equatorial comparisons.
14	16 43 10·93	+3·88	127 18 43·2	+ 2·3	Wash. Cat. 1860, 6943; Cape Cat. 1880, 9128.
13	16 40 50·2	+3·82	127 2 24	+ 2·5	Anonymous = 8 mag. Equatorial comparisons.
14	16 43 10·93	+3·84	127 18 43·2	+ 2·3	Wash. Cat. 1860, 6943; Cape Cat. 1880, 9128.
15	16 48 20·77	+3·86	126 59 54·5	+ 1·8	" 1860, 6997.
16	16 58 29·89	+3·90	127 3 58·2	+ 0·8	" 1860, 7082; Cape Cat. 1880, 9295.
17	16 58 32·80	+3·89	126 56 16·8	+ 0·8	" 1860, 7083.
16	16 58 29·89	+3·88	127 3 58·2	+ 0·8	" 1860, 7082; Cape Cat. 1880, 9295.
17	16 58 32·80	+3·88	126 56 16·8	+ 0·8	" 1860, 7083.
17	16 58 32·80	+3·86	126 56 16·8	+ 0·9	" 1860, 7083.
16	16 58 29·89	+3·87	127 3 58·2	+ 0·9	" 1860, 7082; Cape Cat. 1880, 9295.
16	16 58 29·89	+3·85	127 3 58·2	+ 0·9	" 1860, 7082; " 1880, 9295.
17	16 58 32·80	+3·83	126 56 16·8	+ 0·9	" 1860, 7083.
18	17 21 5·19	+3·92	126 40 46·8	− 1·3	Wash. Mural Cir. Zone 16, 58; Cape Cat. 1880, 9518.
19	17 19 57·61	+3·91	126 25 24·5	− 1·3	" " 16, 57.
19	17 19 57·61	+3·87	126 25 24·5	− 1·2	" " 16, 57.
18	17 21 5·19	+3·88	126 40 46·8	− 1·2	" " 16, 58; Cape Cat. 1880, 9518.
19	17 19 57·61	+3·83	126 25 24·5	− 1·1	" " 16, 57.
20	17 40 26·85	+3·84	125 51 1·0	− 3·1	Wash. Merid. Trans. Zone 44, 15; Wash. Cat. 1860, 7403; Cape Cat. 1880, 9681.
21	17 45 10·03	+3·85	125 35 30·6	− 3·6	Wash. Merid. Trans. Zone 44, 20; Wash. Obs. 1873, 476; Wash. Obs. 1874, 343; Cape Cat. 1880, 9734.

Private Observatory,
Windsor, N.S. Wales:
1884, *Sept.* 10.

Approximate Elliptic Elements of Comet 1884 (*Barnard*). By W. H. Finlay, B.A.

I computed a parabolic orbit for this comet in August, but was unable to represent the middle place satisfactorily. As a similar result was found in Europe, and as M. Stechert's ephemeris in *Astr. Nach.*, No. 2609, showed large discordances from my later observations, I have computed elliptic elements with the following result. The observations used, viz. July 27, August 22, and September 17, were corrected for parallax from the parabolic orbit. The approximations to Q were not carried as far as perhaps they should have been, but the approximation was quite close enough to show whether the comet was moving in an ellipse, and if so, to give a very fair value of the periodic time.

τ	August $16^d\!\cdot\!50950$ G.M.T.	
π	$306^\circ\ 3'\ 40''$	Mean Equinox and Elliptic 1884·0.
☊	$4\ 54\ 1$	
ι	$5\ 30\ 36$	
log. a	0·5017524	
ϕ	$36\ 34\ 31$	
μ	$627''\!\cdot\!159$	
Period	5·6615 years	

These elements leave a discordance $c-o$ in the middle place of $-8''$ *in longitude and* $-1''$ *in latitude.* The month of October, since the Moon drew away from the evening sky, has been completely clouded until last night, October 14, when I secured a fine comparison of the comet with Arg. Oeltz. 21151. This observation compared with the above elements gives the discordance ($c-o$).

$$d\alpha \cos\delta = -\ 5^s\!\cdot\!0$$

$$d\delta = -11''\!\cdot\!0$$

Royal Observatory,
Cape of Good Hope:
1884, *Oct.* 15.

Errata in Vol. XLIII., No. 1, November 1882.

(Communicated by the Astronomer Royal.)

Observations of Comet a, 1882, S.P. with the Transit Circle.

(Page 27.)

			h m s		h m s
May 12	Greenwich Mean Solar Time,	*for*	8 52 15	*read*	8 52 13
	R.A.	"	0 14 19·68	"	0 14 17·46
15	R.A.	"	1 26 20·62	"	1 26 19·51
19	Greenwich Mean Solar Time	"	10 48 58	"	10 49 0
	R.A.	"	2 38 58·01	"	2 38 59·06

The corrections on May 12 and 15 are owing to errors of computation in taking the means of the wires, the usual practice of neglecting the minutes and decades of seconds in the summation of the wires having been followed in this case, to which it is not applicable on account of the uncertainty of observation of the middle wire exceeding 1^s.

Observations of Comet c, 1884 (Wolf), made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations with the East or Sheepshanks Equatorial and the Lassell Reflector were made by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination.

*Observations of Comet c, 1884, **with the Transit Circle.***

1884.	Greenwich Mean Solar Time.	Observer.	R.A.	N.P.D. (corrected for Refraction and Parallax).
d	h m s		h m s	° ′ ″
Sept. 25	8 57 39	J. P.	21 17 57·74	69 49 14·21
27	8 51 9	L.	21 19 19·24	70 45 12·75
28	8 47 58	A. D.	21 20 4·16	71 13 55·99

September 25.—A very faint object, diffused at edges but slightly condensed towards centre. Object confused with illuminated wires. The observation of N.P.D. very rough, the horizontal wire being unilluminated.

September 27.—Extremely faint patch of light, brighter towards centre. Observation of N.P.D. not very good.

September 28.—Fairly bright in dark field with nucleus.

Observations of Comet c, 1884, with the East Equatorial, aperture 6·7 inches.

Observer, A. D.

Greenwich Mean Solar Time. 1884.	☄ − ✱ R.A.	Corr. for Par. and Refrac. in R.A.	☄ − ✱ N.P.D.	Corr. for Par. and Refrac. in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	
d h m s	m s	s	′ ″	″		h m s	° ′ ″	
Sept. 28 7 54 23	−1 5·60	−0·10	+5 10·8	−5·1	4	21 20 1·08	71 12 15·6	*a*

Comet very faint but with stellar nucleus; moon bright; clouds passing.

Observations of Comet c, 1884, with the Lassell Reflector, aperture 24 inches.

Greenwich Mean Solar Time. 1884.	☄ − ✱ R.A.	Corr. for Par. and Refract. in R.A.	☄ − ✱ N.P.D.	Corr. for Par. and Refract. in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	
			Observer, H.					
d h m s	m s	s	′ ″	″		h m	° ′	
Nov. 7 9 38 51	−1 23·94	+0·26	+0 11·1	−7·5	4			*b*
9 45 17	+1 24·01	+0·26	−3 56·4	−7·7	2			*c*
9 57 18	+4 30·32	+0·27	−2 14·3	−7·6	2	22 23 54·56	89 9 58·8	*d*
10 3 56	+0 54·79	+0·29	−5 0·2	−7·8	1	22 23 55·87	89 10 23·8	*e*
9 57 18	+3 14·66	+0·28	−3 43·3	−7·7	2			*f*
			Observer, A. D.					
Nov. 8 9 16 47	+0 22·78	+0·22	−2 11·8	−7·6	4	22 26 2·91	89 30 42·3	*g*
9 27 51	−0 16·64	+0·24	−5 36·2	−7·8	3	22 26 7·80	89 28 53·2	*h*
9 42 53	+1 37·19	+0·24	+3 28·3	−7·3	3	22 26 5·30	89 29 11·7	*i*

Assumed Mean Places of the Comparison Stars.

Star.	Star's Name.	R.A. 1884·0	N.P.D. 1884·0	
		h m s	° ′ ″	
a	B. F. 2925	21 21 3·28	71 7 35·1	3 meridian observations at Greenwich.
b	Anonymous			
c	"			
d	π Aquarii	22 19 21·10	89 12 38·8	Greenwich 7 year Catalogue, 1864.
e	Arg. Z. + 0° − 4878	22 22 57·92	89 15 49·6	Bonn. Obs. vol. vi.
f	Anonymous			
g	Arg. Z. + 0° − 4887	22 25 36·97	89 33 19·8	Bonn. Obs. vol. iii.
h	Arg. Z. + 0° − 4889	22 26 21·27	89 34 55·1	"
i	Arg. Z. + 0° − 4884	22 24 24·94	89 26 9·0	"

November 7.—Comet very faint at last observation. Moon rising.

November 8.—Some difficulty in finding comet as thin clouds were constantly coming up; but comet bright with nucleus when the sky was clear. A small star seen through the nebulous envelope. Wires seen with difficulty, transits rough in consequence.

The observations are corrected for parallax and refraction. The initials A. D., L., H., and J. P. are those of Mr. Downing, Mr. Lewis, Mr. Hollis, and Mr. J. Power.

Occultations of Stars by the

Observed at the Davidson Observatory, San Francisco, California,

(*Communicated by*

No.	Date 1883.		Star.	Estimated Mag.	Phase.	Obs.	Telescope. Ap. inch.	Telescope. Power diam.	Chronom.
1	Jan.	14	Yarnall 413	7½–8	Im.	C.B.H.	6·4	90?	Sid. 223
2			Anon.	8½–9	"	"	6·4	90	"
3			Arg. + 7° : 119 (?)	7½–8	"	"	6·4	90	"
4			Anon.	8–8½	"	"	6·4	90	"
5		15	Arg. + 11° : 218 (?)	8	"	"	6·4	90	"
6			Arg. + 11° : 217 (?)	8½	"	"	6·4	90	"
7	Apr.	16	14 Sextantis	—	"	"	6·4	120	"
8	May	10	λ Geminorum	—	"	"	6·4	90	"
9	June	12	Anon.	8½	"	"	6·4	150	Sid. 3479
10			B.A.C. 4020	7½	"	"	6·4	150	"
11	Sept.	11	ϕ^1 Sagittarii	—	"	G.F.D.	6·4	40	"
12			ϕ^1 Sagittarii	—	"	C.B.H.	3·0	105	Sid. 223
13		12	(R.A. $20^h\ 10^m$ $\delta - 15°{\cdot}6$)	8½	"	"	6·4	90	Sid. 3479
14			β^1 Capricorni	—	"	G.D.	6·4	120	"
15			β^2 Capricorni	—	"	"	6·4	120	"
16			β^2 Capricorni	—	"	C.B.H.	3·0	40	Sid. 223
17	Nov.	4	(R.A. $18^h\ 35^m$ $\delta - 18°{\cdot}7$)	9½–10	"	"	6·4	—	M.T. 5038

(*a*) Hazy, blurred, and tremulous, but disappearance sharp. Felt a slight doubt as to whether ✱ disappeared *just* previous to 59·5 beat or 60·0 beat.

On a New Solar Eyepiece. By Adam Hilger.

Several forms of eyepieces have been contrived for the purpose of diminishing the light and heat from the Sun in a degree sufficiently great to permit of the using of large apertures without inconvenience to the observer.

One of the best known prisms is that which was devised by Sir John Herschel, in which a prism is used whose first surface is placed at an angle of 45°; only about one-twentieth part of its light is reflected on to the eye, the other nineteen-twentieths passing out of the telescope.

In 1871 Professor Pickering (*Proceedings American Academy of Arts and Sciences*, Feb. 14, 1871) devised an ingenious modification of this plan by cementing a second prism on to the first prism by a substance whose index of reflection is very nearly equal to that of the glass. In consequence an exceedingly small

Moon, 1883. By George Davidson.

during the year 1883. Lat. 37° 47′ 24″·1 N., and Long. 122° 25′ 37″·6 W.

the Secretaries.)

Chron. Time as recorded.	Correction to Chron.	Observations. Local Mean Time.	Observations. Local Sid. Time.	Remarks.
h m s	m s	h m s	h m s	
3 23 40·8	−3 53·55	7 42 44·5	3 19 47·2	Good. * about 5′ S. of centre
4 6 38·5	−3 53·62	8 25 35·2	4 2 44·9	Pretty good. * nearly at centre.
4 15 28·3	−3 53·63	8 34 23·5	4 11 34·7	Good. * about 8′ S.
4 17 21·4	−3 53·64	8 36 16·3	4 13 27·8	Good. * about 11′ N. of centre
1 55 3·5	−3 55·90	6 10 23·5	1 51 7·6	* about 10′ S. of centre.
1 58 46·9	−3 55·90	6 14 6·3	1 54 51·0	* about at centre.
11 37 3·4	−1 22·67	9 55 33·3	11 35 40·7	Very good.
12 30 59·45	−0 24·09	9 15 56·3	12 30 34·5	(*a*)
14 10 25·7	−0 15·40	8 45 30·8	14 10 10·3	Nearly at centre.
14 25 10·0	−0 15·40	9 0 12·6	14 24 54·6	About 5′ N. of centre.
21 27 48·8	+0 3·40	10 4 13·2	21 27 52·2	G.D. marked time. Recorded $48^{s}·9 - 0^{s}·1$.
21 28 38·2	−0 46·85	10 4 12·4	21 27 51·4	? $38^{s}·7$ (*b*)
21 41 16·0	+0 4·63	10 13 43·5	21 41 20·6	* *just* S. of centre.
0 6 17·2	+0 4·75	12 38 21·1	0 6 22·0	
0 [14] 50·1	+0 4·76	12 45 52·8	0 13 54·9	Minutes assumed 13.
0 14 43·3	−0 48·46	12 45 52·8	0 13 54·8	
6 52 38·8	+5 58·18	6 58 37·0	21 54 39·3	* very faint, obsn. doubtful. Not in Wash. zones.

(*b*) I heard G.F.D.'s call, and disappearance to my eye happened $0^{s}·2$ to $0^{s}·3$ before the sound reached me, or at $48^{s}·5$ on his chronometer. Carried beats 6 or 7 minutes, and mine may have been one beat in error.—C.B.H.

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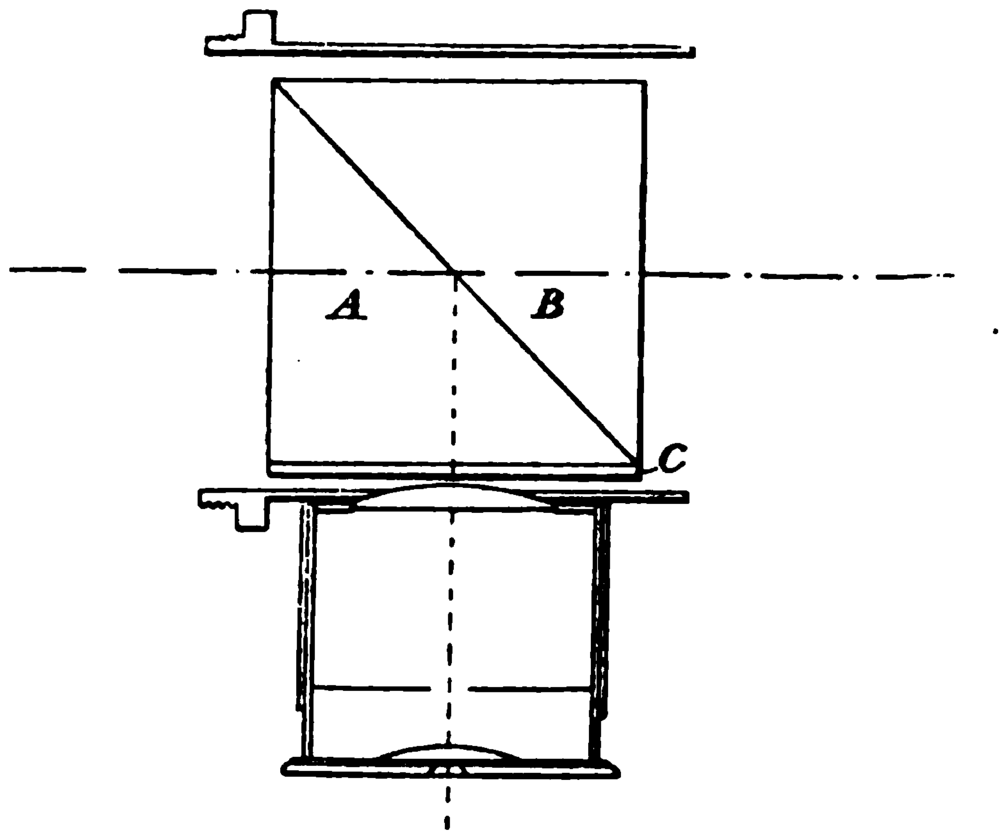
fraction of the total light is reflected, nearly all the light and heat passing out of the telescope.

It is obvious, however, that in this arrangement there is the drawback of the existence of two reflections, one at the surface of the cementing layer, and a second reflection at the surface of the second prism.

Professor Pickering relied upon the extreme thinness of the layer of Canada balsam, which was the cement used, for the sensible superposition, and merging into one of the two reflections, so that the definition should not be impaired by any noticeable duplication of the image.

I have constructed several of these eyepieces, but I have not been able to make the cementing layer so thin, but that with high powers the definition begins to break down, being sensibly impaired by the double reflection. In the new form of eye-

piece which I have now the honour to submit to the Society I have succeeded in doing away with the second reflection, and at once restoring the quality of the definition to that which the telescope is capable of giving, and also at the same time reducing to nearly one-half the amount of light reflected to the eye. I



have accomplished this improvement by making the second prism B of solid Canada balsam contained in a glass cell, of which the surface of the first prism forms one side. There is consequently one reflection only, where the first prism A meets the solid Canada balsam at the angle of 45°.

The first prism is made of glass, whose index of refraction is very near that of the solid balsam.

The amount of light reflected is so small that large apertures may be used without any further protection to the eye.

To reduce still more the amount of light, especially if very large apertures were used, I cemented a thin plate of neutral tint glass C on the surface of the prism A, where the light emerges after reflection. An eyepiece of pale neutral tint glass I found also to produce the same effect as the thin parallel neutral tint plate.

I consider the eyepiece will be found most generally useful in the form which it is described in this paper, with a pale neutral tint plate permanently cemented to the face of the prism.

The two principal advantages which I venture to claim for this new eyepiece are:—

1st. No impairment of definition when high powers are used.

2nd. A further diminution of the small fraction of light reflected by Professor Pickering's eyepiece to nearly one-half.

Erratum.

Vol. XLIV., page 452, line 11 from below, *for* 20°·25, *read* 12°·25.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. DECEMBER 12, 1884. No. 2

EDWIN DUNKIN, F.R.S., President, in the Chair.

Henry Park Hollis, B.A., Royal Observatory, Greenwich, S.E.;
Thomas Henry Hovenden, Selhurst Road, South Norwood;
Thomas Lewis, Royal Observatory, Greenwich, S.E.;
Lord McLaren, 46 Moray Place, Edinburgh;
Rev. William James Boden Roome, The Manse, Aldershot;
Harold Seward, B.A., Patent Office, Southampton Buildings, Chancery Lane;
Rev. Henry Wheaton, M.D., 9 Star Hill Terrace, Rochester; and
Rev. J. Wilkins, 16 Barforth Road, Peckham Rye, S.E.,

were balloted for and duly elected Fellows of the Society.

Note upon the Right Ascensions of certain Standard Polar Stars.

By Prof. Truman Henry Safford.

I should be glad to call the attention of observers in the Society to the need of more systematic observation of the stars of high northern declination. There are systematic discrepancies of a personal character between the Right Ascensions of stars near the Pole as determined by different observers, a fact which has been long recognised but little investigated, except quite lately; and the researches already made are largely unpublished. It would be desirable, I think, to insert in the principal star catalogues, as they are formed, more stars within a few degrees of the Pole than the number which would precisely correspond to the relative area of that region; or, in other

words, to extend the scheme of observation to fainter magnitude there than elsewhere. Practical reasons connected with geodetic astronomy make this also desirable.

A branch of philosophical study—physiological psychology—has lately been brought into relation with this subject by Professor Wundt, of Leipzig, and other investigators; and astronomers, especially in large observatories and in colleges, have the power, while contributing to their own science, to add valuable materials of observation to a far distant inquiry. The psycho-physical experiments proper will necessarily be less conclusive in certain directions than the astronomical, because the latter are the results of thoroughly trained professional ability, while the former will have more variety but be made with less fixity of habit.

The stars included in the following list are given in the American or the French Ephemerides, but are not in the Berlin *Jahrbuch* or the *Nautical Almanac*. Their use as standard polars is very often a great convenience, but is rendered difficult by the fact that their tabular places are derived from investigations made a good while ago, and are now uncertain or incorrect.

I have made a least-square determination of their proper motions from the best available material, and have, with the help of these proper motions, brought up the observations made since 1860. The tabular places corrected are for Nos. 1, 2, 5, those of the American *Ephemeris*, and for the remainder those of the *Annales du Bureau des Longitudes*, tome premier. The Ephemerides of 7 and 9, together with two stars also given in the Berlin *Jahrbuch*, are published in a small annual pamphlet by the Bureau des Longitudes, and those of the five others in the *Connaissance des Temps*.

No.	Star's Name.	Correction to Tabular Right Ascension. A.	B.	C.		Adopted. Right Ascension. 1885·0.	Declin.
		s	s	s	s	h m s	° ′
1	Groom. 944	−0·12		−0·38	−0·011 (t−1885)	5 25 14·76	85 8
2	Camel. 25 H.	−0·44		−0·58	−0·008 (t−1885)	7 6 49·23	82 38
3	Groom. 1119	+6·16	+5·65	+6·1	+0·32 (t−1885)	7 41 4·71	88 58
4	Bradley 1672	+2·36	+1·87	+1·6	+0·063 (t−1885)	12 14 19·98	88 20
5	Camel. 32 H.	−0·42		−0·30	−0·009 (t−1885)	12 48 17·22	84 2
	Groom. 2283	−2·22	−2·32	−2·2	−0·089 (t−1885)	15 14 36·74	87 40
	Bradley 2701	+0·15	−0·30	+0·2	+0·008 (t−1885)	20 34 2·92	81 3
8	Groom. 3548	−0·71	−0·98	−0·76	−0·017 (t−1885)	21 22 23·71	86 34
9	Cephei 32 H.	+0·31	−0·25			22 22 18·48	85 32
	Cephei 39 H.	−0·08	−0·40			23 27 50·20	86 10

The corrections in column A are derived from my own observations for 1882–3, published in the *Proceedings of the American Academy* for 1884; those in column B from M. Gon-

nessiat's, at Lyons, in the *Comptes Rendus* for August 13, 1883; and those in column C from the combination of several determinations to which I have alluded. For stars 9 and 10 the correction was very small, and has been omitted. The corrections in one or two cases are quite sensible. The largest, for Groombridge 1119, is about $0^s\cdot1$ when reduced to the parallel, and arises from a large error in Groombridge's Right Ascension. He seems, like all observers of his time, to have adjusted the instrument rather too rarely, so that it was probably $0^s\cdot2$ or $3''$ of arc from its proper position in the region near the Pole when this star was observed; the error in his case is made absolutely certain by non-agreement of his position with a long series of others, especially Struve 1815, as well as by the increasing deviations from the positions of the *Connaissance des Temps*. The case of star No. 6 is similar. A revision of Groombridge's right ascensions in the immediate region of the Pole has long seemed to me a necessity. The instrumental corrections needed are probably quite as marked for his Meridian Circle as for the transit instruments at Greenwich in Maskelyne and Pond's time.

The comparison of M. Gonnessiat's Right Ascensions of close polars with my own, as given in my paper in the *Proceedings of the American Academy*, p. 347 of the last volume, shows that it is a little doubtful how to investigate and apply the peculiar personal equations which have been long recognised in this region. Not a very small part of them may, perhaps, be due to the cessation of the ordinary personal equation, if the eye-and-ear method be employed throughout. The observer is no longer liable to one kind of psychical disturbance, namely, that produced by the *rapidity* of the star's motion; and it may have been that peculiar anxiety which produced the large discrepancy between Bessel and Struve, for instance. There is no startling improbability in referring the whole constant difference between M. Gonnessiat and myself, about $0^s\cdot4$ for the seven stars given here, to our different clock corrections, assuming that our methods of observing polars are identical.

Whatever be the form of personal equation here, there is no doubt that it would be interesting to follow it out; and I venture to request those astronomers who have well-mounted transits to pay some greater attention to the stars of this list, and any other close polars to the 7th or 8th magnitude.

Williamstown, Mass.:
1884, *Nov.* 27.

On Systematic Errors in the Readings of the Circle Microscopes of the Cape Transit-Circle. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape.

In the *Monthly Notices* for November 1876 Mr. Christie publishes an important paper "On the Effect of Wear in the Micrometer Screws of the Greenwich Transit-Circle."

The Cape Observations from 1871 to 1874 contain no reference to the existence of such errors in the Cape Transit-Circle; but, presumably by Mr. Christie's paper above referred to, the attention of Mr. Stone was directed to the question, for in January 1877 a series of Nadir observations was made on four days extending over the whole range of the screws, and in his Introductions to the Cape Observations for 1875 and 1876 Mr. Stone gives an example of the differences of Nadir, which he considers to be "about as large as the greatest difference obtained throughout the range of the screws employed in the observations." Mr. Stone further concludes that these errors are not due to wear, but that they existed when the screws were new, and were due to constraint, because the last two or three threads of the screw are not so highly finished as the rest.

I shall consider these conclusions of Mr. Stone at a further stage of the present paper.

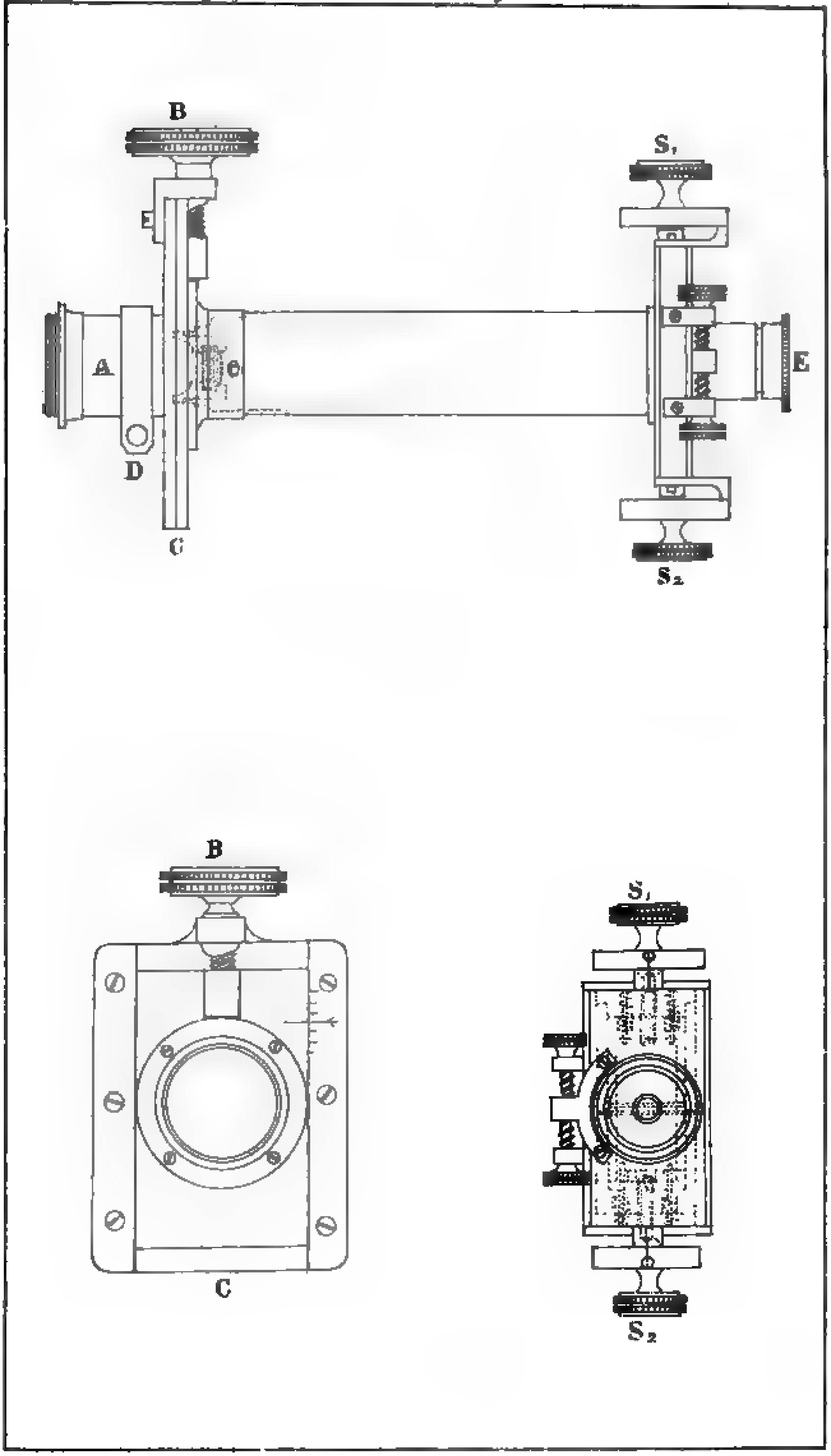
One of the first points, therefore, to which I turned my attention, after assuming direction of the Observatory in 1879, was to examine the condition of the screws of the Transit-Circle.

When the screws were properly cleaned and oiled there was no sign of constraint of the kind mentioned by Mr. Stone; the screws worked freely enough in their bushes throughout their whole range, though several of the slides had a tendency to stick towards the extremity of their range, from a cause that will be presently explained.

I thought it, however, best to have new screws with plenty of free, unconstrained range, and also to have an apparatus constructed by which the errors of the screws could be readily and minutely determined from time to time. The cause of the sticking of the slides appeared to be a defect in the design of the microscopes. The circular shoulders of the screws rested in hollow conical bearings that were *not* attached to the box of the micrometer, but to solid brass projections cast on the brass ring which is bolted to the pier, and upon which are also cast the hollow cylindrical projections to which the micrometer boxes are attached.

[The ring and projections in question are shown in section on Plate IX. of Sir George Airy's description of the Transit-Circle (Greenwich Observations 1852 and 1867) and in elevation on Plate VII.]

If the micrometer boxes had been rigidly attached to these hollow projections all might have been well, but the boxes were fixed to them by means of screws tapped into the ends of the



Jellicoe del. ... Lith.

hollow cylindrical projections, and the holes in the flanges of the micrometer boxes through which these screws passed were widened to allow adjustment of the boxes. Now, it is obvious that any shift of the micrometer box, except in the line of the axis of the screw, would at once derange the parallelism of the axis of the screw with its matrix and the slide. Such change would also shift the circle of bearing of the shoulder of the screw in the hollow cone, and might even cause the shoulder to bear on one side only of the hollow cone. The periodic errors of micrometer screws have origin more frequently in their bearings than in the thread of the screw; every time, therefore, that the micrometer box is removed for the purpose of cleaning or oiling the slide, it would be necessary to re-examine the errors of the screws, to say nothing of the risk of introducing a one-sided bearing of the shoulder, or a tendency in the slide to stick or jam.

The first thing, therefore, was to remove the micrometer boxes, and to have the bearings of the screw shoulders attached permanently to the ends of the boxes. This work was admirably executed by Mr. Simms, who also made an exquisite set of new screws. At the same time the old cross-wires by which the divisions were read were removed, and the more modern pattern of parallel wires, embracing the division, was introduced. The original eye-end was also sent home for repair (its draw-tube fits better than that of the new eye-end recently made), and was returned by Mr. Simms with new screws and in perfect working order.

For examining the errors of the screws I designed an apparatus of the following description, which has been admirably executed by Mr. Simms:

E O is a micrometer microscope, of which the object-glass is at O, the eye-piece at E, and the screws for moving its webs at S_1 and S_2. This microscope is attached to the micrometer (of which the screw is to be investigated) by the adapter A.

In the common focus of the object-glass O and the eye-piece E there are two pairs of parallel wires; one pair moved by the screw S_1, the other by the screw S_2. These wires are adjusted in focus of the objective, and to parallelism with the movable wire of the micrometer under examination, by means of a sliding tube in the adapter A, the latter being finally clamped by the clamp D.

With this apparatus the errors of the screws of the eye-end and of the microscope micrometers were investigated as follows:

By means of the slide B C, acted on by the screw B, the whole apparatus can be moved so as to command successively the whole range of the screw.

The screws were first tested for equality of the whole revolutions, the double wires (moved by S_1 and S_2) being set to a distance corresponding with one revolution of the micrometer screw under examination, and this distance was then measured in terms of successive revolutions of each micrometer screw.

The following table shows the excess of the length of each revolution of each screw over the length of a mean revolution of that screw. Each figure is the result of five or six sets of observations made by two or three different observers:

The screw-heads are divided into 100 parts.

	0r to 1r.	1r to 2r.	2r to 3r.	3r to 4r.	4r to 5r.
	r	r	r	r	r
Microscope A	−0·0013	+·0011	+·0009	−·0007	−·0001
„ B	− 5	+ 7	− 5	+ 1	+ 4
„ C	− 6	+ 4	+ 4	0	− 2
„ D	− 15	+ 9	+ 8	− 6	+ 3
„ E	− 6	− 3	− 5	+ 3	+ 9
„ F	− 13	− 10	+ 6	+ 12	+ 5
Mean ...	−0·0010	+·0003	+·0003	+·0001	+·0003

These errors were regarded as insignificant.

The periodic errors have been similarly investigated, employing a constant distance = about 0r·33.

The results are given in the following table:—

Measure beginning	r·0	r·1	r·2	r·3	r·4	r·5	r·6	r·7	r·8	r·9
A	−·0034	−·0034	−·0016	+·0010	+·0003	+·0003	+·0005	+·0009	+·0024	−·0004
B	− 4	− 10	− 14	+ 3	+ 5	+ 8	+ 8	− 6	+ 12	− 3
C	+ 38	+ 32	+ 26	− 15	− 32	− 36	− 23	− 9	+ 4	+ 15
D	− 3	− 2	+ 8	+ 9	+ 5	− 9	+ 9	− 5	− 8	− 4
E	− 15	− 16	− 19	− 3	+ 10	+ 11	+ 17	+ 17	+ 2	− 4
F	− 15	− 16	− 2	+ 7	+ 16	+ 20	+ 9	+ 3	− 11	− 13

The corrections to be applied to the readings of each screw-head were then computed from the above determinations by Bessel's method. The resulting corrections are:

For Screw A	−·00125 cos u	+·00022 sin u	−·00010 cos $2u$	−·00108 sin $2u$
„ B	− 35	− 20	+ 39	− 35
„ C	+ 186	− 83	− 28	+ 36
„ D	+ 5	+ 34	− 16	00
„ E	− 103	− 7	+ 4	− 5
„ F	− 77	+ 66	+ 11	− 3

The corresponding corrections in arc are:

	r·0	r·1	r·2	r·3	r·4	r·5	r·6	r·7	r·8	r·9
A	−0″·084	−″·121	−″·046	+″·082	+″·133	+″·072	−″·011	−″·024	+″·007	−″·009
B	+ ·002	−·038	−·052	−·012	−·038	+·046	+·012	−·014	−·002	+·018
C	+ ·098	+·078	+·014	−·082	−·151	−·133	−·090	+·041	+·086	+·097
D	− ·007	+·012	+·029	+·027	+·007	−·013	−·018	−·013	−·011	−·013
E	− ·062	−·057	−·028	+·016	+·053	+·067	+·052	+·021	−·016	−·045
F	− ·041	−·011	+·024	+·056	+·070	+·055	+·011	−·037	−·065	−·063
Mean	−0·016	−·023	−·010	+·015	+·025	+·016	−·007	−·004	·000	−·003

These corrections compensate each other so perfectly in the mean that, if the readings of all the micrometer heads are nearly the same, the maximum error of the mean will be $\pm 0''\cdot025$. The eccentricity of the circle has been determined with great care and found to be $2''\cdot20$, and the distances between the microscopes are almost exactly equal, so that the readings of the microscopes are never very different in practice.

In practice the Declination Micrometer Screw is used only over about four revolutions. The normal setting is 30^r, and the observers are instructed to clamp the instrument so that the star under observation shall transit within $\pm 2^r$ of this reading. The examination of the screw was therefore confined to the six central revolutions, viz. 27^r to 33^r.

A space equal to about two revolutions of the Declination Micrometer Screw was set off on the screw-testing apparatus, and measured with the following results:

27^r to 29^r.	29^r to 31^r.	31^r to 33^r.
r	r	r
$-\cdot0001$	$-\cdot0006$	$+\cdot0007$

The space 27^r to 30^r was also compared with 30^r to 33^r with the following results:

27^r to 30^r.	30^r to 33^r.
r	r
$+\cdot0010$	$-\cdot0010$

The screw may therefore be considered practically perfect as to equality in the whole revolutions.

The periodic errors were then investigated precisely in the same manner as those of the Circle Microscopes, and found to be, from six sets of measures of a space $= 0^r\cdot33$:

$$+\cdot00073 \cos u - \cdot00012 \sin u - \cdot00089 \cos 2u - \cdot00008 \sin 2u.$$

The value of one revolution of the screw is $28''\cdot580$, so that the corrections to be applied to the screw readings expressed in arc are:

$^r\cdot0$	$^r\cdot1$	$^r\cdot2$	$^r\cdot3$	$^r\cdot4$	$^r\cdot5$	$^r\cdot6$	$^r\cdot7$	$^r\cdot8$	$^r\cdot9$
$-''\cdot004$	$+''\cdot005$	$+''\cdot022$	$+''\cdot012$	$-''\cdot024$	$-''\cdot046$	$-''\cdot025$	$+''\cdot015$	$+''\cdot031$	$+''\cdot013$

These errors I considered too insignificant for application, seeing that the same star will generally be bisected by different parts of the screw at each observed culmination.

All these investigations were made in March 1880, and it seemed that all the screws might be regarded as perfect within limits of error far less than $0''\cdot1$. But on my return from England in September of the present year, and in examining the results of work done in my absence, I observed a marked variation in the run of the microscopes, which seemed to depend

on the part of the microscope screws employed in the determination.

To investigate this point the following determinations of run were made, each result being the mean of four determinations (extending over the whole range of the screws on each of two different days) by each of two observers.

As a matter of convenience the usual notation of the readings is increased by 5^r, so that in the following paper the readings commonly recorded 0^r and 5^r will be denoted 5^r and 10^r respectively.

The runs of each microscope were thus found to be the following:

TABLE I.

Lower reading of Mic. A.	Equivalents of 5′ in terms of each Micrometer Screw.						
	A	B	C	D	E	F	Mean.
	r	r	r	r	r	r	r
2·0	4·7920	4·8128	4·8128	4·7765	4·8179	4·7920	4·8007
2·33	·7890	·8135	·8146	·7811	·8140	·7944	·8011
2·67	·7926	·8136	·8065	·7791	·8174	·7970	·8010
3·0	·7920	·8109	·8086	·7786	·8191	·7967	·8010
3·33	·7935	·8129	·8118	·7851	·8188	·7973	·8032
3·67	·7979	·8105	·8036	·7848	·8217	·7974	·8027
4·0	·7993	·8094	·8065	·7875	·8231	·8013	·8045
4·33	·8000	·8087	·8116	·7949	·8233	·8016	·8067
4·67	·8069	·8137	·8060	·7986	·8272	·8090	·8102
5·00	·8196	·8139	·8106	·8106	·8305	·8127	·8163
5·33	·8292	·8207	·8176	·8316	·8380	·8206	·8263
5·67	·8376	·8264	·8193	·8470	·8457	·8255	·8336
6·00	·8433	·8251	·8195	·8533	·8486	·8298	·8366
6·33	·8401	·8285	·8242	·8601	·8485	·8280	·8382
6·67	·8457	·8286	·8248	·8656	·8508	·8334	·8415

These results are corrected for the small periodic errors of the screws.

The probable error of each of these results for the separate microscopes, as deduced from the agreement of the eight separate sets, is $\pm 0^r \cdot 00098$, so that we may consider each figure in the mean result to represent the mean of the screw readings with a probable error of $\pm 0^r \cdot 0004$. There can be no doubt, therefore, as to the systematic character of the variation of the runs, not only in the mean, but for each separate microscope. The law of this variation is also of the same general character, although the actual amount of variation is very different in the different microscopes. I could hardly believe it possible that

errors of such an extent had been produced by wear in little more than four years; for if such errors were produced in four years, to what would they amount in twenty-four years?—that is, from the erection of the Transit-Circle in 1855 till the new screws were made in 1879. I began to suspect that the errors were produced by optical distortion of the field of the microscopes.

The observed variations in run depend on the *difference* of the errors at the upper and lower readings of the screws, and in order to arrive at an approximate knowledge of their character I assumed that the errors depending on the reading of the mean screw could be represented by the series:

$$\text{True reading} = n + an^2 + bn^3 + \&c. \quad . \quad . \quad .$$

This series had to be carried to the fifth power of n before any reasonable representation of the observations was arrived at. The correction to be applied to the mean reading of the six microscopes was then found to be:

$$35\cdot56n - 22\cdot91n^2 - 6\cdot162n^3 + 0\cdot636n^4 + 0\cdot1788n^5,$$

the unit being $\frac{1}{10000}$ of a revolution, and n being reckoned from $7^{r}\cdot0$. With this expression the mean observations of Table I. are represented as follows:

Screw Readings.		Observed Excess of Mean.	Computed Excess of Mean.	C−O.
r	r	r	r	r
2·0 and	6·8	+0·0142	+0·0136	−·0006
2·33	7·13	+ 138	+ 136	− 2
2·67	7·47	+ 139	+ 144	+ 5
3·0	7·80	+ 139	+ 143	+ 4
3·33	8·13	+ 117	+ 141	+ 24
3·67	8·47	+ 122	+ 128	+ 6
4·00	8·80	+ 104	+ 102	− 2
4·33	9·13	+ 82	+ 65	− 17
4·67	9·47	+ 47	+ 16	− 31
5·00	9·80	− 14	− 37	− 23
5·33	10·13	− 144	− 94	− 20
5·67	10·47	− 187	− 155	+ 32
6·0	10·80	− 217	− 208	+ 9
6·33	11·13	− 233	− 247	− 14
6·67	11·47	− 266	− 267	− 1

It is obvious from these residuals that to obtain a representation of the observations within limits of their probable errors

it would be necessary to include terms to the seventh power of *n*. The solution is, however, sufficiently exact as it stands for the purpose of determining the general character of the errors and of tracing their probable source.

The corrections to be applied to the screw readings according to this solution are:

Screw Reading.	Correction.	Screw Reading.	Correction.
r	r	r	r
2·0	−·0143	7·0	±·0000
2·5	− 134	7·5	+ 12
3·0	− 134	8·0	+ 7
3·5	− 139	8·5	− 14
4·0	− 139	9·0	− 54
4·5	− 129	9·5	− 108
5·0	− 109	10·0	− 171
5·5	− 82	10·5	− 232
6·0	− 52	11·0	− 273
6·5	− 23	11·5	− 273

We may now obtain a pretty accurate notion of the cause of these errors. The corrections are practically the same from $2^{r}{\cdot}0$ to $4^{r}{\cdot}5$ where the screw is never used; they attain a maximum at $7^{r}{\cdot}5$ where the screw is most used; and they again become uniform after $10^{r}{\cdot}5$, which is beyond the part of the screw used in regular work. All this points to *wear* as the source of the errors in question; let us see if the sign of these corrections corresponds with what it would be in case of wear. Suppose that the screw readings increase as the spiral spring of the slide is compressed. If, then, the screw thread is worn at any part, the slide will not be so far moved against the spring for the same reading of the head as it would have been if the screw thread were not worn; or to make the bisection of a division we have to move the head farther (i.e. to a greater reading) than if the screw were not worn; the correction on account of wear would therefore be negative. But in the Cape Circle the screw readings all diminish as the spring is compressed, so that the reading for greatest wear of the screw requires the greatest + correction; and this corresponds with what we have found above.

As a further test, I mounted four supplementary microscopes. For these Mr. Simms also made new screws in 1880, but they have never been used except in determining the errors of division of the Circle. The screws were therefore practically unworn. Similar observations with those of Table I. for the run of these microscopes were made with the following results, each figure, however, depending on four sets of observations only:

TABLE II.

Mean Runs of the Screws of the Four Supplementary Microscopes.

Lower Reading of Mic. A.	Equivalent of 5′ of arc.	Excess of Mean.
	r	r
2·0	4·8228	− ·0005
3·0	·8230	− 3
4·0	·8228	− 5
5·0	·8247	+ 14
6·0	·8223	− 10
7·0	·8242	+ 11

Here the runs are found to be identical, within limits of error of observation, for all parts of the screw, proving that the whole of the errors exhibited in Table I. have been produced by wear of the screws, and are not due to optical distortion.

As a further test, the following observations of Nadir point were made by Mr. Pett and Mr. Cox in 1884, October 15:

The ten microscopes were read at each observation, and the Nadir points have been worked out separately for the six microscopes in ordinary use, and for the four microscopes with unworn screws. The results are:

TABLE III.

Nadir Point.

Reading of Mic. A.	Six Microscopes in daily use.*	Four Microscopes with unworn screws.
r	′ ″	′ ″
5	5 0·99	4 54·55
6	·48	·49
7	·19	·41
8	·08	·42
9	·06	·31
10	·59	·52

The screw corrections (determined for the six microscopes from our discussion of the results of Table I.) we now see more clearly to be defective, because we have forced an expression, which is the equation for a continuous curve, to represent what is in reality a curve terminating at either extremity in a straight line. But if we apply even these corrections to the Nadir points of Table III. which were determined with the six microscopes, we obtain the following more accordant results

* For the results of this column the runs were derived from the usual observations for run.

Reading of Micrometer A.	Nadir from six Microscopes approx. corrected for screw error.*
r	′ ″
5	5 0·62
6	0·57
7	0·73
8	0·78
9	0·52
10	0·47

These much smaller discordances still exceed the errors of observation (as the non-representation of Table I. by the same correction also shows), and I await the arrival of the screw-testing apparatus from England † to make a complete and independent investigation of the errors of each screw.‡

Meanwhile, having shown that, in a period of four and a quarter years, such large errors have been produced in the screws by wear alone, it becomes most interesting and important to determine all that can now be ascertained as to the errors of the screws between 1870 and 1879, when the observations for Mr. Stone's great Catalogue were made. The Transit-Circle was brought into use in 1855, the screws in 1875 had therefore been subjected to wear for twenty years.

The only data that I have been able to find which permit any approximate estimate of the errors of the screws to be made is a series of Nadir observations made in 1877, January 13, 14, 24, and 31. On each of these days the coincidence of the reflected with the direct image of the Declination wire was observed at different readings of the Declination Micrometer screw, whilst the same six divisions of the Circle were read by the Circle Microscopes. If all the screws were free from error, such observations enable us—

1. To find the runs of the Circle Microscope screws if the value of the Declination Micrometer screw is known ; or,

2. To find the value of the Declination Micrometer screw if the runs of the microscope screws are known or determined.

But if the screws of the Circle Microscopes are affected by errors, it is not possible, without a knowledge of these errors, to determine the run, as the run will vary according to the part of the screw employed in its determination. In such a case it is only possible to select some convenient part of the screw as standard to which all our run-determinations shall be referred,

* Here the corrections for screw error were of course applied to the observations before the runs employed were computed.

† The apparatus was sent to Mr. Simms to be adapted to other micrometers used at the Observatory.

‡ It is of course necessary to have some such means to compare smaller portions than 5 revolutions of the screw with each other.

and then afterwards to determine the errors of the screw with reference to this distance.

There exist no data for separating the errors of the Declination Micrometer screw from those of the Micrometer Microscopes; we can therefore only assume, at least in the first place, that the Declination screw is without error, and that, being a steel screw, it is probably much less liable to wear than the gun-metal screws of the Circle Microscopes. The value of the Declination screw was determined by Sir T. Maclear with great care on the following occasions:

	Over arc of 15'.	Over arc of 5'.
	$''$	$'$
1855, Jan. 29	1 rev. = 28·584†	
1862, Aug. 22	= ·583*	28·547*
30	= ·584†	·548†

Mr. Stone has, with Sir T. Maclear, adopted the value 28′·548, as the arcs measured with the Declination Micrometer screw are all less than 5′, and I have employed the same value in reducing the Nadir observations of 1877, June 13, 14, 24, and 31.

For the run it was important to determine whether this could be assumed uniform for the dates in question. The unknown errors of the screws rendered it impossible to employ the separate runs determined on each of these dates, because they were made at different parts of the screws, and were not therefore comparable. An examination of the runs, extending over long periods, during which no changes were made in the adjustments of the microscopes, reveals the fact that the apparent variations of run are produced entirely by the errors of the screws, and by the errors of division of the different spaces measured, and that the runs are not sensibly affected by changes of temperature, but that the *real* run is practically constant. The reader can satisfy himself on the latter point by taking the means of the runs in the various months of the year from the Cape Observations for 1876 (when the observers appear to have been instructed to make the lower reading for run between $5^{r}\cdot1$ and $5^{r}\cdot3$), or, better still, from the observations for 1856, when the screws were not worn, and the runs were determined at uniformly distributed parts of the Circle. There was no change in the microscope adjustments in January 1877, and I have therefore re-reduced the Nadir point determinations in question, employing a uniform mean run which represents the run of the screw from the determinations in that month, when the lower reading is about $5^{r}\cdot2$ and the upper therefore about $10^{r}\cdot0$.

* From observations of the Nadir.

† From observations on the South Collimators.

The Nadir readings of 1877, January 13, 14, 24, and 31, were on each day extended over the greater part of the range of the Circle Microscope screws, so that by comparing the Nadirs determined on the different days with similar parts of the microscope screws we can arrive at the real changes of Nadir on the different days, and thus reduce them to a uniform system. In this way the corrections applicable to the results of each day to reduce all to January 14 were found to be:

For Jan.	13	$-0''.15$
	24	-1.03
	31	-1.56

The results so reduced and arranged in order of the readings of Microscope A are the following:

TABLE IV.

Nadir Points observed 1877, *January* 13, 14, 24, and 27.

		Reading of Microscope A.	Observed Nadir Point.
		r	° ′ ″
Jan.	24	4 32	180 7 10.63
	24	·77	10.75
	31	·81	10 76
	24	·88	10.79
	14	·92	10.60
	24	5.98	10.42
	31	5.03	9.99
	24	·08	10.14
	31	·19	9.67
	24	·21	9.69
	24	·33	9.78
	14	·34	9.38
	31	·37	9.69
	24	·42	9.64
	31	·54	9.68
	24	·62	9 67
	14	·76	9.65
	31	5.97	9.58
	13	6.02	9.28
	13	·04	9.31
	14	·40	9.49
	31	·47	9.29
	24	·80	9.31

	Reading of Microscope A.	Observed Nadir Point.
	r	° ′ ″
Jan. 14	·86	180 7 9·53
31	6·97	9·40
13	7·32	9·47
31	·48	9·20
14	·70	9·23
31	·97	9·26
14	7·98	9·47
24	8·06	9·24
13	·26	9·49
14	8·81	9·32
31	9·00	9·62
24	·12	9·43
13	·46	9·37
14	9·84	9·59
31	10·03	9·69
24	·15	9·60
31	·45	10·03
14	·48	10·01
14	·61	10·08
24	·79	9·71
13	·91	10·01

The variations in these Nadir points are the result of the combined errors of the Declination Micrometer screw and of the Circle Micrometer screws, together with the error of the adopted value in arc of the Circle Micrometer screws (i.e. of the adopted run) relative to the adopted value of the declination screw.

For determining the errors of the Circle Micrometer screws it is practically immaterial within certain limits what value of the run is adopted; the effect of changing the value of the adopted run would simply be to produce a coincidence in the value of the Nadir points at two different readings separated by 4·8 revolutions. But as we have employed the mean run derived from independent run-determinations made when the lower reading of Microscope A is near $5^{r}\cdot2$, the Nadir point comes out nearly the same at $5^{r}\cdot2$ and at $10^{r}\cdot0$ (i.e. $5^{r}\cdot2+4^{r}\cdot8$)—a proof that the adopted value of the Declination Micrometer screw is nearly absolutely correct. If therefore the Declination Micrometer screw is free from irregularities, the discordances of the Nadir exhibited in Table IV. are produced by errors which correspond with the mean of the errors of the screws of the Circle Microscopes.

It becomes important therefore to consider what are the probable effects of irregularities in the Declination Micrometer screw on these results. My experience of screws made by Mr. Simms is that their errors are very small when the screws have not been subject to wear, and from the following observations by Sir T. Maclear we may conclude that such was the case in the screw in question.

1862, August 26.

Measurements of the distance between two dots on the cross of the South Collimator, nearly 1ʳ apart, on different parts of the Declination Micrometer Screw.

		Obs.−Mean.			Obs.−Mean.
r	r	r	r	r	r
34·6 to	35·6	−·003	49·5 to	50·5	−·001
35·7	36·7	− 3	50·6	51·6	− 1
36·8	37·8	− 5	51·7	52·7	+ 1
37·9	38·9	− 1	52·8	53·8	− 1
38·9	39·9	− 4	53·8	54·8	− 1
39·9	40·9	+ 2	54·9	55·9	+ 1
41·1	42·1	− 3	55·9	56·9	− 1
42·2	43·2	− 5	57·0	58·0	+ 2
43·2	44·2	− 4	58·0	59·1	+ 3
44·3	45·3	− 1	59·2	60·2	+ 3
45·3	46·3	+ 4	60·2	61·2	− 6
46·3	47·3	+ 7	61·3	62·3	− 1
47·4	48·4	− 3	62·4	63·4	+ 5
48·4	49·5	+ 8			

With regard to these observations Maclear remarks, "The differences from mean do not perhaps exceed the limit of the errors of observation, as the dots observed were not very well defined or regular in outline."

He also measured with the Declination Micrometer two dots nearly $9^{r}\cdot4$ apart.

		1st Obs.	2nd Obs.	3rd Obs.	Mean.
r	r	r	r	r	r
35·0 to	44·4 =	9·404	·405	·402	9·404
44·4	53·8 =	9·413	·417	·411	9·414
53·8	63·2 =	9·396	·406	·399	9·399

From an examination of the original observations I find that $50^{r}\cdot0$ was adopted as the micrometer reading for the centre of the field, and that the Transit-Circle was clamped so that the star always transited near the centre of the field; thus the vast majority of the observations were made with the reading of the micrometer screw $50^{r} \pm 1^{r}$, and that only in exceptional cases were readings of 48^{r} or 52^{r} employed, whilst readings of 47^{r} and

53^r are very rare. From January 1871 till May 1872 it appears to have been the custom to make the Nadir observations when Microscope A read about $0^r\cdot3$, corresponding with a declination micrometer reading about $54^r\cdot5$. After that date the Nadir readings were made near the middle of the range of the screw—that is, when Micrometer A read nearly $2^r\cdot5$ and the Declination Micrometer about $50^r\cdot0$. Thus at least 90 per cent. of all the observations were made within one or two revolutions of $50^r\cdot0$, and about this point, therefore, we should have the maximum of wear, whilst the screw below 48^r and above 52^r should be practically free from wear. But our Table IV. shows that the *greatest changes in the Nadirs occur* when the readings of Microscope A are below $5^r\cdot9$ and above $9^r\cdot0$, corresponding with Declination Micrometer readings above $53^r\cdot2$ and below $46^r\cdot5$—that is, *where the screw is not worn*, and where its irregularities are very small. We are therefore compelled to attribute the whole of the great discordances in the Nadir points shown in Table IV. to errors in the screws of the Circle Microscopes. That is to say, the screws are practically perfect (unworn) from $4^r\cdot3$ to $4^r\cdot9$, then the errors run down rapidly during the next revolution, are then practically uniform till $9^r\cdot5$, when they again run up rapidly, becoming uniform from $10^r\cdot4$ onwards. I attribute these errors to wear on the evidence of the first part of the present paper, but Mr. Stone insists so positively that the large errors of the screw which he found below $5^r\cdot0$ are due to constraint, that I think it necessary to state more fully my reasons for differing from him on the question.

Mr. Stone puts his argument in the following words:

It may be mentioned that, since the commencement of our re-observation of Lacaille's zones in 1871, negative readings of the Circle Microscopes have been systematically avoided both in the direct observations and in the determinations for the corrections for runs. I noticed that some of the screws of the Circle Microscopes came under constraint when readings below 0^r of Microscope A in the present position of the microscopes and their combs were made. The assistants were, in consequence, instructed not to take readings on the negative side of Microscope A, and such readings have since been but very seldom taken, and then only through inadvertency, and when the readings fell close to the zero. Our Nadir point readings are never taken, for use, with readings of Microscope A so low as 0^r, and are usually taken near the middle of the range of screws.

The following determinations of the reading for the Nadir point may be interesting, as showing the kind of systematic errors which may exist in our work from the combined errors of microscope screws, declination screw, and the assumed values of their revolutions.

1875, *Nov.* 22. *Nadir Point Readings.*

Observer.		Reading of A. 0^r	2^r
E. J. S. ...	...	180° 7′ 26″·62	26″·28
W. H. F. ...	...	26·55	26·37
G. H. M. ...	...	26·70	26·22
Mean	...	26·62	26·29

It appears from observations made in 1877, and carried systematically over the whole range of screws, that the difference above indicated is real; but is about as large as the greatest difference obtained throughout the range of the screws employed in the observations.

Errors, which I believe to have the same origin, existed when the screws were new, and are conspicuous in some determinations of the runs made about 1857 and 1858, when occasionally the starting-point for the run was taken some distance on the negative side of the zero. Such errors may, unless carefully guarded against, become of serious amount. The source of these errors may, in my opinion, be indicated as follows:

The effective range of the screws in the Cape microscopes does not extend, at most, over more than six revolutions; for the last two threads certainly, and probably the last three near the base of the screw, are not so highly finished as those threads near the middle range of the screw which, I suppose, were intended to be, and which at all events have been, most generally used.

It requires, therefore, some care to adjust the microscopes so that the several readings shall not differ greatly among themselves, and yet all the screws work sweetly over the run of a 5′ division on the circle. In all cases when the last two or three threads become engaged the commencement of constraint can be felt and the readings at once begin to become defective. When the runs are determined from a starting point at which some of the microscopes are under constraint, while the readings at the other end are taken with microscopes free from constraint, the result may be that the error arising from constraint will be carried by the run correction to its full extent, and with the same sign into all readings made near the other end of the run; at intermediate points the errors will be smaller and will decrease with great rapidity until the state of constraint be passed, after which they will only depend on the erroneous correction for runs, and will increase proportionally to the reading. It has been to escape the use of any of the microscopes under constraint that negative readings have been avoided.

With reference to these remarks, it is well to examine the evidence as to the runs with negative readings in 1855 when the screws were new (i.e. the runs when the lower reading is below $5^{r}\cdot 0$).

There are only two such readings recorded in 1855, but I give also the two first of the same kind in 1856. Fortunately there are also other determinations of run on the same days for comparison.

Determinations of Run in 1855 and 1856 at different parts of the Circle Microscope Screws.

	Lower Reading of Circle Microscopes.	Pointer Reading.	Run.
	r	°	r
1855, Nov. 25	4·76	70	4·804
	5·46	90	·820
Dec. 5	4·74	360	4·812
	5·24	240	·804
1856, Jan. 6	4·53	270	4·813
	5·64	250	·813
Feb. 17	4·90	60	4·818
	0·36	80	·814

The mean result is that:

For negative readings the run = 4·812

For normal „ = 4·813

There is nothing here to justify the remark that errors having origin in constraint were "conspicuous" when the screws were new.

Let us now take some similar examples of run at a much later period. There are no examples of runs with negative readings taken after December 1875. The following are the whole of the examples that occur in 1874 and 1875:

	Lower Reading of Circle Microscopes.	Pointer Reading.	Run.
	r	° ′	r
1874, June 7	4·7	34 55	4·778
	5·3	31 20	·791
July 21	4·7	35 35	4·783
	5·7	36 10	·795
Nov. 28	4·8	36 10	4·783
	0·3	37 35	·798
1875, July 6	4·8	26 30	4·784
	5·7	27 15	·797
Oct. 28	4·8	313 25	4·783
	5·5	25 40	·803

In the mean:

When negative readings are employed the run is = 4·782 r

When normal „ „ = ·797

What is the cause of this difference—a difference that did not exist when the screws were new, but which is so marked after eighteen or twenty years' wear? Mr. Stone says it is "constraint" produced because the last two or three threads near the base of the screw are not so highly finished as those threads near the middle of the range. But this theory is incompatible with the following facts:

1. A careful examination of one of the old screws (the screw of an original spare microscope micrometer that can be adapted to the pointer for special purposes) shows that there is no difference in finish between the threads near the base and the rest of the screw. There is, in fact, no shoulder to the screw, but the thread has been cut for several revolutions beyond its present terminal point, and then these threads have been removed by turning. Anyone conversant with the process of making such a screw also knows that it would be much more troublesome and difficult to finish one part of the screw less

carefully than another part than to finish all parts alike, and that Mr. Simms is not likely to take such trouble in order to make the screws designedly imperfect.

2. If there is such constraint as Mr. Stone describes, it is quite inexplicable why it should not exist in 1855–56, and be so very marked in 1874 and 1875.

3. Such constraint is utterly inconsistent with the facts of Table IV., which show that from $4^{r}.3$ to $4^{r}.9$ the screws are perfectly uniform.

Mr. Stone appears to have somewhat incautiously ascribed the errors to constraint because sometimes the action of the screws became stiff for readings below $5^{r}.0$. But if the screws are very seldom used below $5^{r}.0$, there is no doubt that immediately below $5^{r}.0$ there would be a considerable and abrupt accumulation of dirt and congealed oil which would render the screws difficult of rotation for readings below $5^{r}.0$; or there might have been a mal-adjustment of the micrometer box relative to the screw, as I have shown to be possible before the bearing of the shoulder of the screw was attached to the box. One cannot now precisely say what caused the "constraint" mentioned by Mr. Stone; I can only state that there are occasional notes, such as "the screws turned stiffly," followed soon after by a note that the screws were cleaned, and then there are no more notes about stiffness of the screws for a long time.

But if "constraint" did exist, one is puzzled to understand how it can explain the results of Table IV. Does Mr. Stone mean that the difficulty of moving the slide was such as to create a tension on the screw sufficient to elongate it $\frac{1}{50}$ of a revolution (or to twist its head relative to the thread engaged by $\frac{1}{50}$ of a revolution), or to bend the thick and solid projection which carried the hollow bearing of the shoulder of the screw by this amount, and that the materials were so perfectly elastic as to perfectly recover their original form and exactly reproduce the same amount of error due to constraint on each occasion? One feels sure that Mr. Stone could not mean this, and yet how otherwise could constraint affect the readings?

But if further proof is required of the erroneousness of Mr. Stone's conclusions, we may examine the errors of the runs at various epochs, and if these errors change progressively we may be satisfied that they are produced by wear.

This is sufficiently exemplified by the following results. The figures inclosed in brackets denote the number of observations upon which each result depends:

Lower Reading of Microscope A.	1856–57.	1872–73.
r r	r	r
4·5 to 4·6	4·811 (3)	
4·6 4·7	·812 (9)	
4·7 4·8	·811 (11)	
4·8 4·9	·811 (19)	4·808 (1)

Lower Reading of Microscope A.		1856–57.	1872–73.
r	r	r	r
4·9 to	5·0	4·811 (26)	
5·0	5·1	·811 (19)	4·821 (11)
5·1	5·2	·813 (28)	·823 (21)
5·2	5·3	·814 (28)	·826 (29)
5·3	5·4	·814 (19)	·828 (40)
5·4	5·5	·815 (15)	·830 (39)
5·5	5·6	·816 (7)	·831 (35)
5·6	5·7	·815 (7)	·831 (15)
5·7	5·8		·833 (6)
5·8	5·9		·835 (4)
5·9	6·0		·831 (6)

After 1873 there is no considerable period without some change in the microscope adjustments, and in which there is any variety in the part of the screw employed in the run determination. Thus, for example, in 1878–79 the lowest reading for run varies only between $5^r\cdot3$ and $5^r\cdot6$. A false impression as to their real uniformity is thus created. There are here and there readings for runs below $5^r\cdot0$, which are sometimes followed by re-adjustments of the microscopes, and notes by Mr. Stone that such runs are wrong, but there is no step taken to determine the cause of the errors or to permit anyone else to do so.

Let us now consider the effect of wear upon a screw. In so doing it will be convenient to imagine the screw unrolled and represented by a wedge, of which A B is the surface that bears upon the female screw cut in the slide, and C B the bearing shoulder.

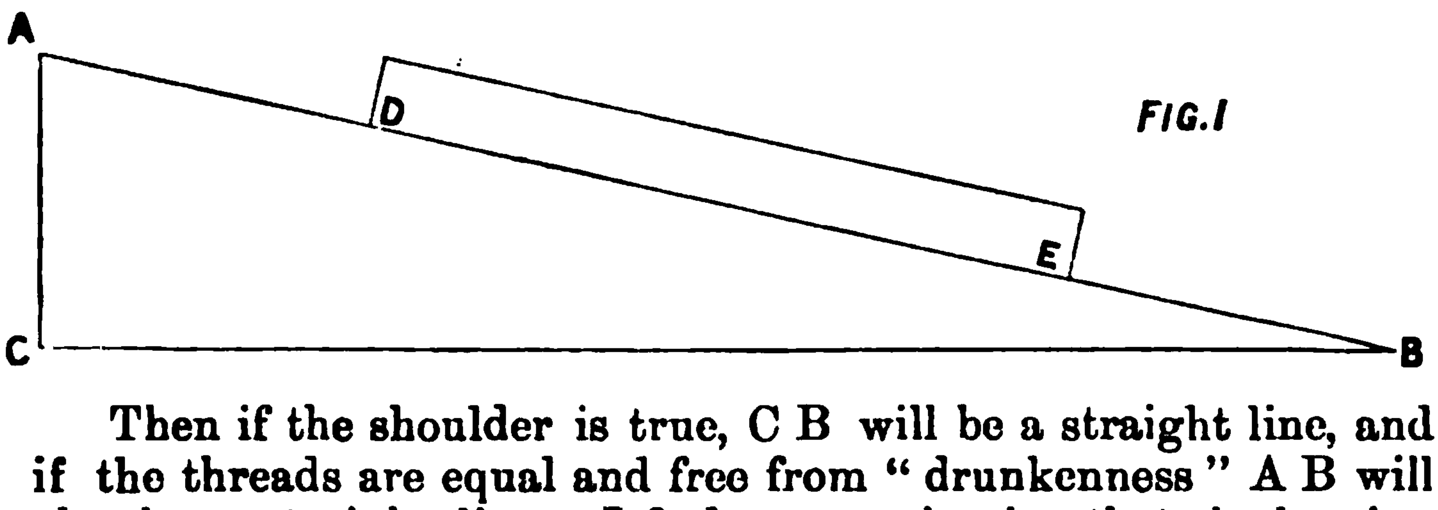
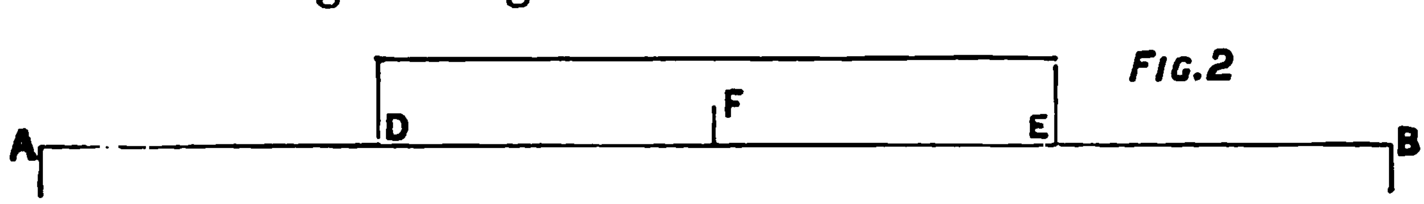


FIG. I

Then if the shoulder is true, C B will be a straight line, and if the threads are equal and free from "drunkenness" A B will also be a straight line. I find on examination that the bearing or female screw embraces eight threads of the micrometer screw; we may therefore represent its bearing surface by that of a block D E extending over eight revolutions of the screw. If this block

FIG. 2



D E is rubbed continually on A B, so that its middle point F

(fig. 2) is brought alternately as far as A and B, then if the surfaces are each uniform in texture throughout, the surfaces, however long the abrasion is continued, will remain plane.

If D E has a shorter sweep, so long as E comes as far as B, and D as far as A, there will be a tendency to make the surface A B slightly hollow and D E slightly convex.

But if the sweep of D E is limited to the points G H, and if we suppose for the moment that the surface D E is incapable of wear, then A B must become worn in the form (fig. 3).

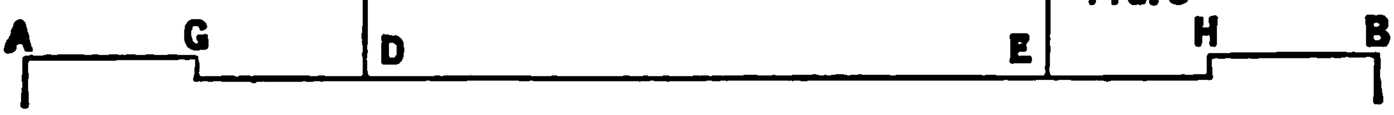


FIG. 3

If we suppose further that the wear, instead of being produced by sweeps which always extend from G to H, is produced by the ordinary use of a micrometer screw—that is to say, if the successive sweeps begin as often at $5+n$ revolutions as at $5+2n$ revolutions, as at $5+3n$ revolutions, and so on, but limited to $5+m$ revolutions, and as a necessity must end as often at the point $5+n$ as at $5+2n$, as at $5+3n$, &c., also limited to $5+m$ revolutions, then the wear of A B will be represented by G *d e* H (fig. 4), where *d e* is a straight line equal in length to D E, and G *d* and A *e* are also straight lines represented in fig. 4.

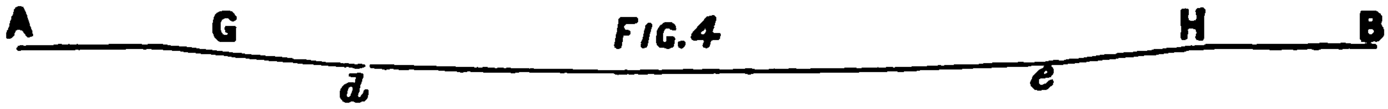


FIG. 4

But these supposed cases cannot occur in practice, because the bearings D E must wear. The calculation of the form of D E and of the now continuous curve G *d e* H therefore involves a knowledge of the relative coefficients of wear of the screw and its bearing, and is further complicated, when one endeavours to go to the root of the matter, by the form of the section of the thread of the micrometer screw and the fit of the female screw. The general form of the wear is, however, for the two surfaces nearly as shown in fig. 5.

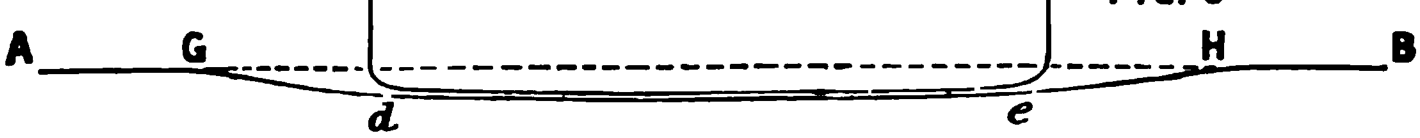


FIG. 5

To obtain in a very easy manner the general form of the resulting errors in the screw readings, imagine the following simple construction:

Let *a s t b* (fig. 6) be a piece of thin wood, of which the upper edge *a g h b* is cut out to a curve representing the worn thread of the screw, and the lower edge *s t* is a straight line parallel to the straight parts of *a b*. On the upper edge of *a b* let there rest *d e*, the lower edge of which is shaped to represent the worn surface of the female screw. Attach a wire *p w* rigidly to *d e*

at right angles to the original unworn surface, and suppose this wire to move smoothly through holes in the fixed blocks *r* and *v*.

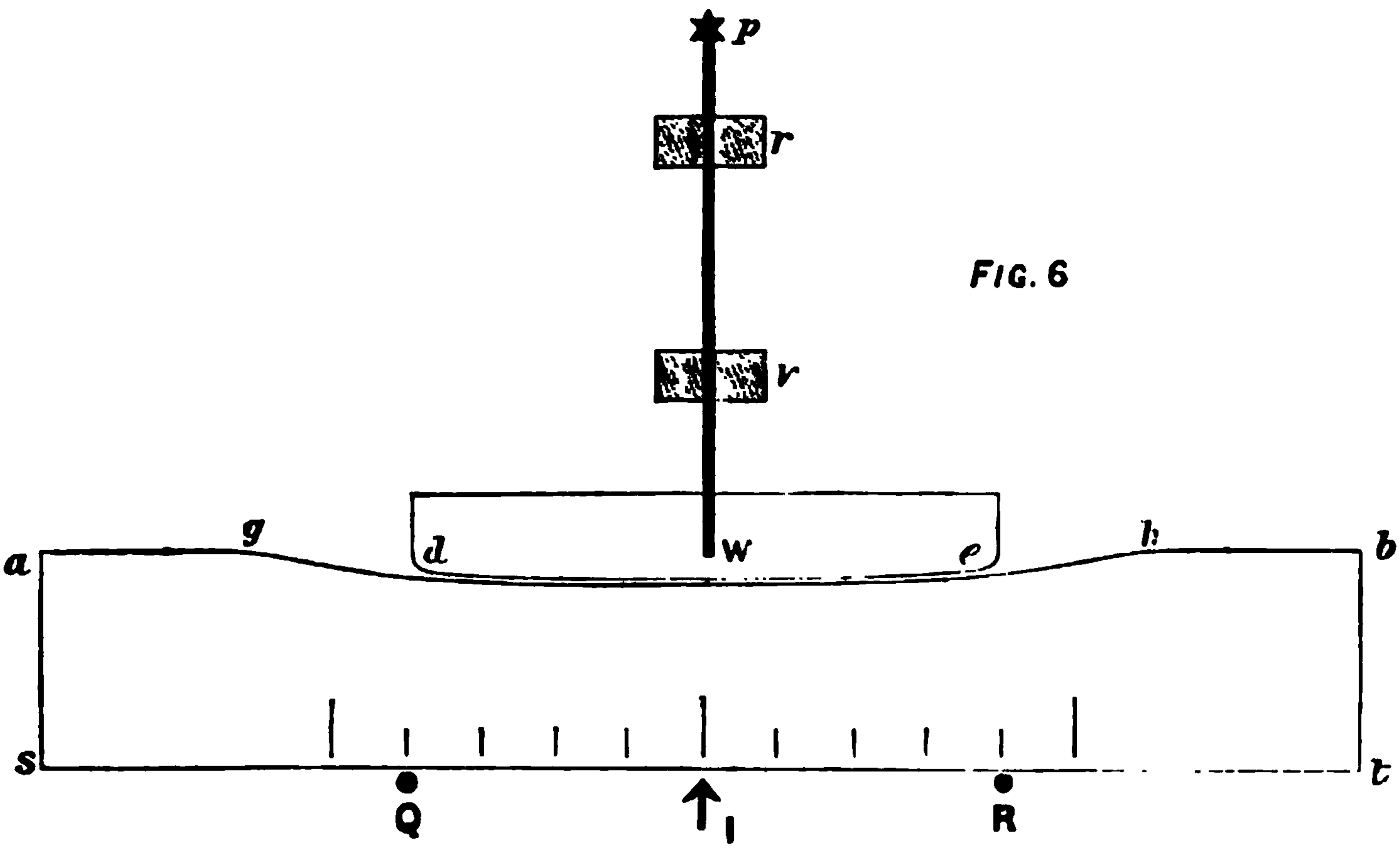


FIG. 6

Let Q and R represent points (immoveable with respect to *r* and *v*), and let *s t* always rest on these points, but be moveable from right to left, or *vice versa*, upon them. Further, let there be an index at I and a graduation on *s t* representing the corresponding readings of the screw (where the reading at I must correspond with the middle reading of the range of the screw when *d e* is in the middle of its range). Since the wire *p w* sliding in the fixed blocks *r* and *v* preserves the parallelism of the original (unworn) surface of *d e* with *s t* (that is, represents the preservation of the parallelism of the axis of the male and female screw which in the micrometer is accomplished by the slide), then, whatever point of the curve *g h* comes in contact with *d e*, that point represents the part of the worn surface of the screw which will be engaged for the corresponding reading of Index I, and the rise and fall of the point *p* (the end of the wire), as *s t* is moved on the points Q and R, will represent the variations of the errors of the screw, corresponding to the various readings of the Index I.

It is obvious, from mere inspection of fig. 6, that for the central parts of the screw the errors will vary very slowly, but that near the extremities of the range they will change with very great rapidity, as we have seen to be the case in practice—viz. in Table IV.

Mr. Christie, in his paper "On the Effect of Wear on the Micrometer Screws of the Greenwich Transit-Circle" (*Monthly Notices*, vol. xxxvii. p. 20), ascribes the large errors between 0^r and 1^r (i.e. in our notation between 5^r and 6^r) as due to a preponderance of a large number of readings which have produced additional wear near that point.

Mr. Stone (*Monthly Notices*, vol. xlii. pp. 33 and 34), in his

note on these conclusions of Mr. Christie (repeated in a series of papers by him on the Greenwich refractions), expresses the following opinion:

Neither 4.000 nor 8,000 additional Nadir observations made near $0^r{\cdot}0$ in a period of eight years would have led to any such serious wear of the screws as that indicated as existing in 1876 near $0^r{\cdot}0$. If all the observations were made near $0^r{\cdot}0$, and the screws were never worked far from this reading, such a thing might be conceivable, but in practice the screws are worked continually backwards and forwards over the whole range of the screws from 0^r to 5^r.

Mr. Stone then proceeds to give "a key to the true explanation of these errors" by the extraordinary statement:

In all screws the threads near the end of the screws are defective, and are never intended to be used.

Now it is well known that Mr. Simms has an excellent screw-cutting engine, and a very limited knowledge of the use of such an engine would show that it would be much more difficult for him to make the threads beyond the normal range defective than to make them as perfect as the rest. Why, therefore, should one assume that in every case trouble is taken to make the last threads of the screw defective? In one case, that of the unworn screws of the Cape Transit-Circle Microscopes α, β, γ, and δ, it is shown in Table II. that they are practically perfect for a much greater range than that in common use, viz. from $2^r{\cdot}0$ to $11^r{\cdot}8$. I have also shown from abstract considerations that if the screws are worked continually backwards and forwards, as in practice, errors resulting from uniform wear will produce errors in the readings which increase very rapidly towards the limit of the range.

I have also shown from Mr. Stone's own observations of Nadir points in January 1876 that errors from wear, similar with those of the Greenwich screws, existed in the screws of the Cape Transit-Circle.

It remains for me now to offer an explanation of the only remaining point, viz., why the errors near 5^r are greater (or rather, change more rapidly) than those near 10^r. It appears to be simply this:

The wear of 5^r must always be greater than at 10^r because the spiral springs are much further compressed (and therefore much greater friction is created) at the former than at the latter reading. Further, if the male screw is so short that beyond 10^r the female screw extends over it, the form of the curve of wear will obviously be much flatter, but I have no means of deciding now whether both causes or only the former cause operated in the case of the old screws.

In the accompanying figure (fig. 7) the separate results of Mr. Stone's Nadir observations, 1876, are laid down, and a curve

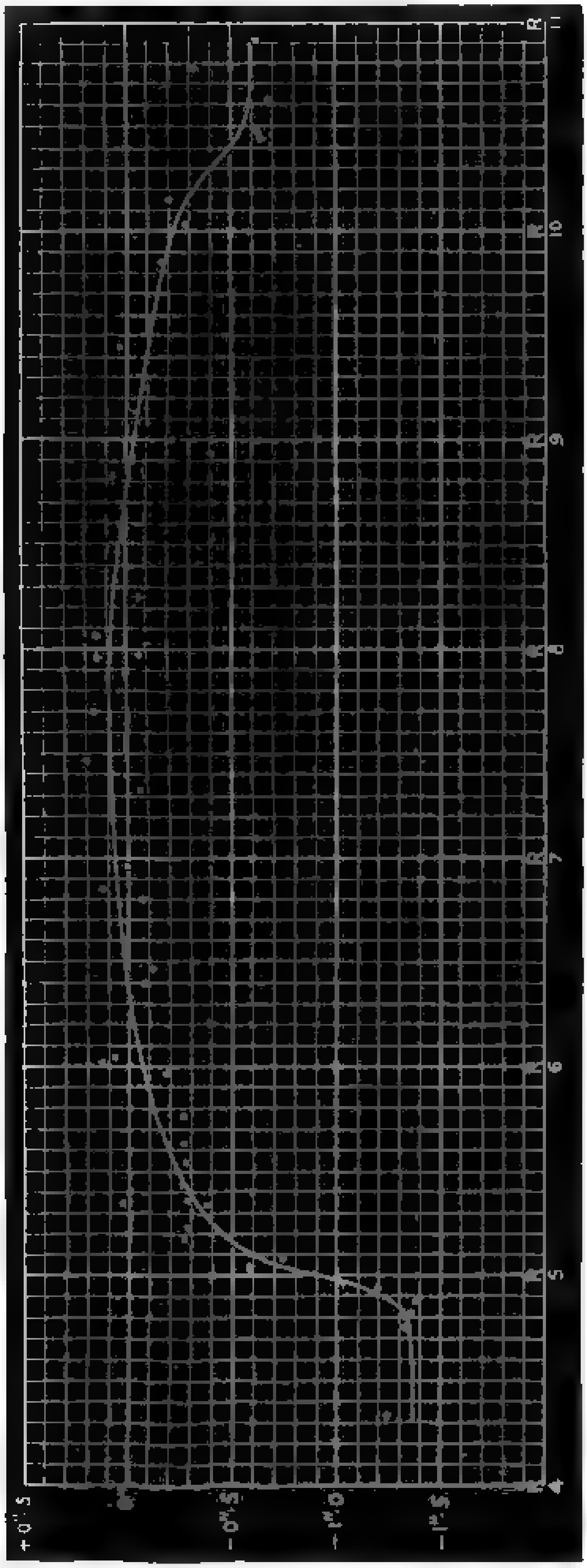


FIG. 7.—Curve showing corrections to Nadir Point according to readings of circle microscopes, deduced from observations made by Mr. Stone in January 1877

has been drawn to represent the observations as accurately as possible.

From this curve the following Table of corrections is obtained:

TABLE V.

Corrections to be applied to the readings of the Micrometer Screws of the Cape Transit-Circle, deduced from Nadir observations made in January 1877.

Rev.	"	Rev.	"	Rev.	"	Rev.	"
4·3	−1·35	6·0	−0·07	7·7	+0·10	9·4	−0·10
·4	−1·35	·1	− ·05	·8	+ ·10	·5	− ·11
·5	−1·35	·2	− ·03	·9	+ ·10	·6	− ·13
·6	−1·35	·3	− ·01	8·0	+ ·09	·7	− ·15
·7	−1·35	·4	·00	·1	+ ·08	·8	− ·17
·8	−1·35	·5	+ ·01	·2	+ ·07	·9	− ·20
·9	−1·20	·6	+ ·02	·3	+ ·06	10·0	− ·23
5·0	−0·95	·7	+ ·03	·4	+ ·05	·1	− ·27
·1	−0·60	·8	+ ·04	·5	+ ·04	·2	− ·32
·2	−0·47	·9	+ ·05	·6	+ ·02	·3	− ·40
·3	−0·36	7·0	+ ·06	·7	·00	·4	− ·50
·4	−0·29	·1	+ ·07	·8	− ·02	·5	− ·56
·5	−0·24	·2	+ ·08	·9	− ·04	·6	− ·58
·6	−0·20	·3	+ ·08	9·0	− ·05	·7	− ·59
·7	−0·15	·4	+ ·08	·1	− ·06	·8	− ·60
·8	−0·12	·5	+ ·09	·2	− ·07	·9	− ·60
·9	−0·10	·6	+ ·09	·3	− ·08	11·0	− ·60

Remembering that 5′ of arc corresponds nearly with 4·8 revolutions, we obtain from Table V. the following Table VI. for correcting the runs on account of errors of the screws.

TABLE VI.

Corrections to be applied (in arc) to the observed equivalent of 5′.

Argument. Lower Reading of Microscope A in Observing Run.	Correction to Equivalent of 5′.	Argument. Lower Reading of Microscope A in Observing Run.	Correction to Equivalent of 5′.
Rev.	"	Rev.	"
4·7	+1·24	5·5	−0·16
4·8	+1·22	5·6	− ·30
4·9	+1·15	5·7	− ·41
5·0	+0·78	5·8	− ·46
5·1	+0·40	5·9	− ·49
5·2	+0·24	6·0	− ·53
5·3	+0·09	6·1	− ·55
5·4	−0·03	6·2	− ·56

The complete correction of an observed N.P.D. for errors of the screws can then be easily obtained from these Tables as follows:—

Put R = the lower reading of Microscope A in the observed determination of run.

N = the reading of Microscope A in the determination of Nadir.

O = " " observation of the star.

r = the correction from Table VI. taken out with the argument R.

n = " Table V. taken out with the argument N.

o = " Table V. taken out with the argument O.

Then the correction to be applied to an observation of N.P.D. (if the adopted latitude is correct) will be (since the readings of the circle increase as the telescope is turned from the Zenith to the South):

$$r\left(\frac{\mathrm{N}-\mathrm{O}}{4 \cdot 8}\right)+o-n.$$

Unfortunately these corrections cannot be embodied in a single Table, but in order that the reader may judge of their influence on the results, two Tables have been prepared, viz.:

Table VII., showing the resulting corrections when the Nadir has been observed at $5^{\mathrm{r}}\cdot 3$, and

Table VIII., showing the corrections when the Nadir has been observed at $7^{\mathrm{r}}\cdot 5$.

From January 1871 till May 1872 the Nadir point observations at the Cape were made with the readings of Microscope A about $5^{\mathrm{r}}\cdot 3$. This was the practice introduced by Mr. Stone at Greenwich in 1868, a practice which, on mistaken grounds, he defends in his "Note on Mr. Christie's Paper" (*Monthly Notices*, xlii. p. 32). Mr. Stone's defence, indeed, is the more strange, seeing that he defends a practice in 1881 which he himself had relinquished in 1872. After May 1872 the Nadir is observed more nearly towards the middle of the screws (i.e. $7^{\mathrm{r}}\cdot 5$).

A comparison between Tables VII. and VIII. will show the large and sudden change which may be introduced into the system of N.P.D. results, viz. of about $+0''\cdot 5$—a change, however, which would have been for the better if the latitude depended upon the same observations.

In the Introduction to the Cape observations, previously quoted at length, Mr. Stone states that a difference of $0''\cdot 33$ between two observations of Nadir, which he quotes, is real, but *is about as large as the greatest difference obtained throughout the range of the screws*; and describes such a difference as "*the kind of systematic errors which may exist in our work from the combined errors of microscopic screws, Declination screw, and the*

TABLE VII.

Nadir supposed taken at 5r 3.

Lower Reading of Microscope A in determining run.	Reading of Microscope A in observing object. 4·8	4·9	5·0	5·1	5·3	6·0	7·0	8·0	9·0	10·0	10·5	11·0
4·8	−0·86	−0·74	−0·51	−0·19	0·00	+0·11	−0·01	−0·24	−0·63	−1·07	−1·52	−1·69
4·9	0·87	0·75	0·52	0·19	0·00	0·12	+0·01	−0·20	0·58	1·00	1·45	1·61
5·0	0·91	0·78	0·54	0·21	0·00	0·17	+0·14	+0·01	−0·29	0·64	1·05	1·17
5·1	0·94	0·80	0·56	0·22	0·00	0·24	0·28	+0·23	0·00	0·26	0·63	0·71
5·2	0·96	0·82	0·57	0·23	0·00	0·26	0·33	0·32	+0·12	−0·11	0·46	0·52
5·3	0·98	0·83	0·58	0·23	0·00	0·28	0·39	0·40	0·24	+0·04	0·30	0·35
5·4	1·00	0·85	0·60	0·25	0·00	0·29	0·43	0·46	0·33	0·16	0·17	0·21
5·5	1·01	0·86	0·60	0·25	0·00	0·31	0·47	0·54	0·43	0·28	0·03	0·05
5·6	1·02	0·86	0·61	0·25	0·00	0·34	0·53	0·62	0·54	0·43	0·13	0·12
5·7	1·03	0·87	0·61	0·26	0·00	0·35	0·57	0·68	0·63	0·53	0·25	0·25
5·8	1·04	0·88	0·62	0·26	0·00	0·36	0·58	0·71	0·66	0·58	0·30	0·31
5·9	−1·05	−0·89	−0·63	−0·27	0·00	+0·36	+0·59	+0·72	+0·68	+0·61	−0·33	−0·34

TABLE VIII.

Nadir supposed taken at 7r·5.

Lower Reading of Microscope A in determining run.	Reading of Microscope A in observing object. 4·8	4·9	5·0	5·1	5·3	6·0	7·0	8·0	9·0	10·0	10·5	11·0
4·8	−0·75	−0·63	−0·40	−0·08	+0·11	+0·22	+0·10	−0·13	−0·52	−0·96	−1·41	−1·58
4·9	0·79	0·67	0·44	0·11	+0·08	0·20	0·09	0·12	0·50	0·92	1·37	1·53
5·0	1·00	0·87	0·63	0·30	−0·09	+0·08	0·05	0·08	0·38	0·73	1·14	1·26
5·1	1·21	1·07	0·83	0·49	0·27	−0·03	+0·01	0·04	0·27	0·53	0·90	0·98
5·2	1·30	1·16	0·91	0·57	0·34	0·08	−0·01	0·02	0·22	0·45	0·80	0·86
5·3	1·39	1·24	0·99	0·64	0·41	0·13	0·02	−0·01	0·17	0·37	0·71	0·76
5·4	1·46	1·31	1·06	0·71	0·46	0·17	0·03	0·00	0·13	0·30	0·63	0·67
5·5	1·53	1·38	1·12	0·77	0·52	0·21	0·05	+0·02	0·09	0·24	0·55	0·57
5·6	1·61	1·45	1·20	0·84	0·59	0·25	0·06	0·03	0·05	0·16	0·46	0·47
5·7	1·67	1·51	1·25	0·90	0·64	0·29	0·07	0·04	−0·01	0·11	0·39	0·39
5·8	1·70	1·54	1·28	0·92	0·66	0·30	0·08	0·05	0·00	0·08	0·36	0·35
5·9	−1·72	−1·56	−1·30	−0·94	−0·67	−0·31	−0·08	+0·05	+0·01	−0·06	−0·34	−0·33

assumed values of their revolutions." It would be interesting to know how Mr. Stone reconciles the former of these statements with the facts of Table IV. observed by himself, and how he reconciles the latter statement with the facts of Tables VII. and VIII.

The general conclusions appear to be:

1. The errors of screws of Transit-Circles require much more frequent examination than it has been customary to give them.

2. Steel screws should be substituted for the present gun-metal screws of the Cape Circle Microscopes, the latter being far too subject to change from wear.

3. Three of the six microscopes should be reversed (as has already been done at Greenwich), so that the springs may press the bearings of the screws in the opposite direction. This precaution, however, is not a complete cure, as the errors produced by wear affect the screw readings most near the point of greatest compression of the spiral springs, and the curve of correction is thus not symmetrical with the middle of the range. Besides this, it will be seen from Table I. that the wear may be very different for the six screws, although doubtless they were supposed to be made of precisely the same material.

4. The N.P.D. results of the *Cape Catalogue* for 1880 must be corrected for screw errors, and the latitude determination be rediscussed before these results can be admitted into any fundamental determination such as that of the constant of refraction. It is not improbable that the large *cosine* term in the flexure which is so marked in 1871 and 1872 may be due in part or in whole to errors of the screw, coupled with systematic observation of the Nadir near $5^{r}\cdot3$, as the N.P.D. of each star will be affected by errors which have a considerable + sign for the most usual readings (see Table VII.).

Royal Observatory,
Cape of Good Hope
1884, *Nov.* 5.

Spectroscopic Observations made at the Earl of Crawford's Observatory, Dun Echt, Aberdeen. By Ralph Copeland, Ph.D.

Under the direction of Lord Crawford a number of sweeps over the heavens have been made here this autumn in search of small nebulæ and other objects with remarkable spectra. The instrument used is the 6·06-in. Simms Equatorial, with a Secchi prism in front of the object-glass. In examining the richer part of the milky way about *Cygnus* four nebulæ and one star with a spectrum of bright lines, which seem not to have been pre-

viously noticed, were found in the earlier sweeps. Later sweeps in the same part of the heavens have not added to the list, although many known nebulæ and red or variable stars have arrested attention. On September 22 Comet Wolf was found by its spectrum, twelve hours before the news of its discovery had reached Dun Echt, the announcement having been accidentally delayed in the telegraph office at Kiel.

The places of the five objects are :—

R.A. 1884.			Decl. 1884.			When found.	Remarks.
h	m	s	°	′	″	1884.	
20	5	9·82	+16	34	53·3	Sept. 17	Equal in brightness to a star 10·2 mag. Diam. *n* and *s* 4″·6 by micrometer. It has an 11 mag. star at 222° 27′, distant 84″·2.
20	6	44·09	+46	7	2·3	Sept. 20	Planetary nebula; most of the light in a single line.
20	7	33·43	+19	38	30·4	Sept. 17	Nebula about 2½″ diam., equal to a 9·8 mag. star. Follows η *Sagittæ* 7^{m} 32^{s}·77, 61″·15 to the south.
20	7	52·99	+38	0	26·8	Sept. 22.	This is the 7·1 mag. star, D.M. +37°,3821. It has a spectrum of several bright lines near D, and a very bright band in wave-length 464 mmm. The place is from B.W.2.
20	9	40	+12	23	3	Sept. 22	This seems to be identical with the 9·5 mag. star D.M.+12°,4266. It is in reality a planetary nebula about 4″ in diameter with a nearly monochromatic spectrum.

The fourth object is probably the most interesting of the series. It is practically a member of the same group as the three stars of the same type found by Messrs. Wolf and Rayet to which Professor Pickering has added a fourth. This is the brightest object of its class in the northern heavens. It is intended to examine its spectrum shortly with improved appliances.

Dun Echt:
1884, *Dec.* 11.

An Occulting Eye-piece. By Edmund J. Spitta, M.R.C.S. Eng., L.R C.P.Lond.

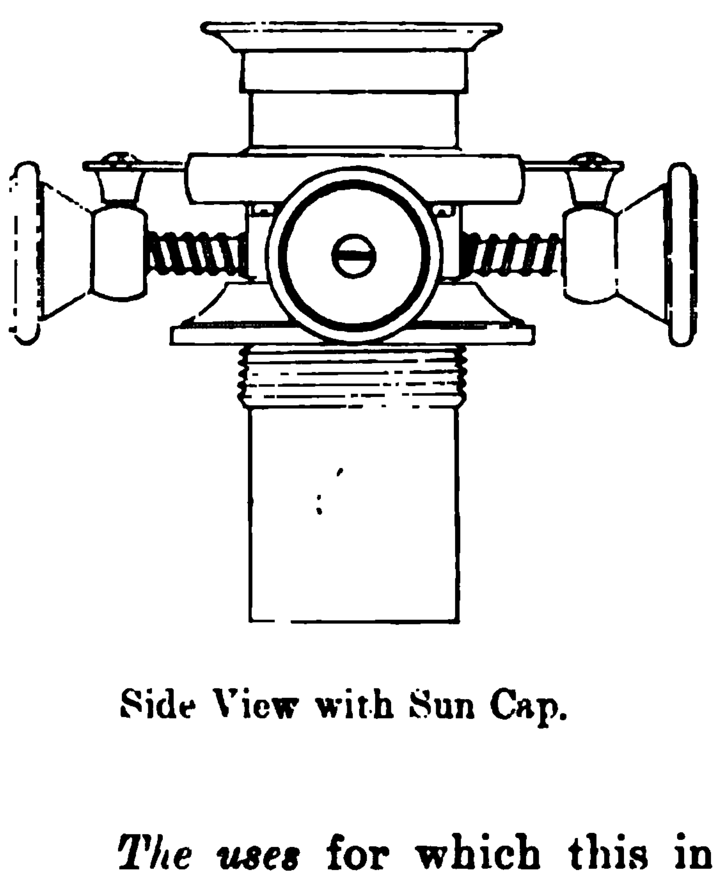
This arrangement consisting essentially of a shallow cylindrical brass box containing four shutters, placed in front of a tube carrying the lenses, is convenient in construction, and when screwed in to the telescope in place of an ordinary eye-piece, does not interfere with the comfort of the observer, is easily under his command, and not weighty enough to require a counterpoise.

The box containing the shutters, about a quarter of an inch deep, and one and a half in diameter, is pierced at its circum-

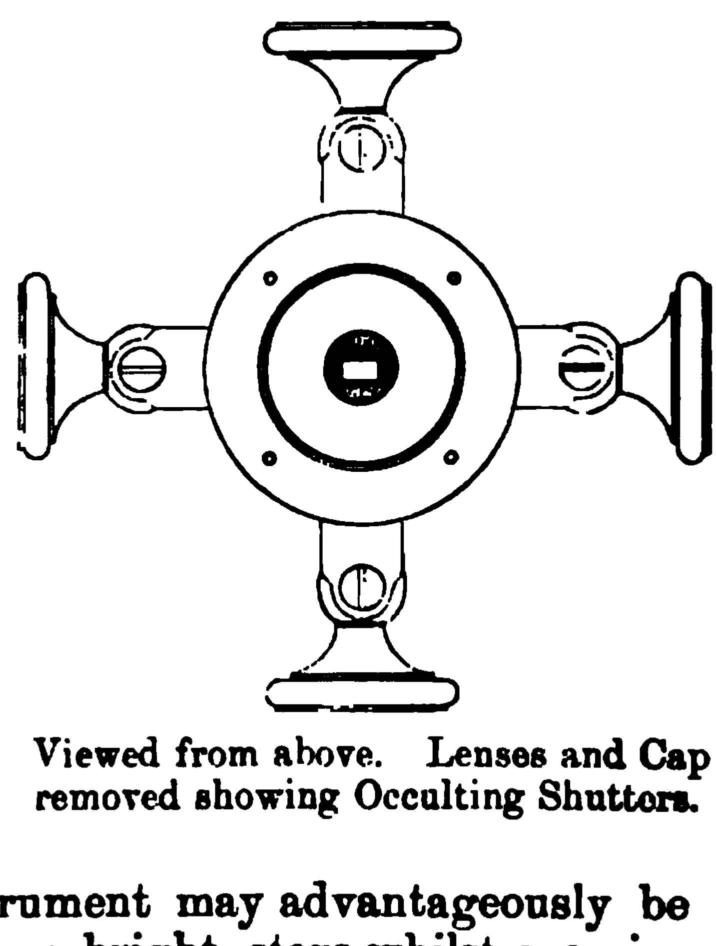
ference by four dove-tailed grooves, planed to allow the "carriers" of the shutters which run in them to move smoothly and regularly to and fro. Attached to the outer end of each carrier, at right angles, is a gun-metal pillar, perforated to hold the milled-headed screw—60 threads to the inch—the observer uses to close or open the shutters, whilst at its central end, that really within the confines of the box itself, is attached the shutter, its occulting end being "knife-edged." Great difficulty was experienced at first in making the four shutters meet in the field without catching against one another, and yet to keep all four in focus. At length this was overcome by bending two opposite ones deeply, the occulting edges being only in the focus, and allowing the others to pass to and fro within the curves of the former two. All are now in focus, and there is no fear of collision.

If one of the screws be turned in the ordinary direction, the corresponding shutter is pushed forward, and the field in that part is gradually occulted, whereas if all four be employed it will be reduced to a four-sided, right-angled figure. By further manipulation it can be shaped into a slit like that of the spectroscope, or minimised still more until it becomes a mere pin-hole.

The lenses, Ramsden's construction, are placed in the cylinder, fixed to the shutter-box, and each is adjusted for its own focus of the shutters—powers 120 and 200 on a 6-foot. Three caps to this cylinder are provided, one with a small and another with a large eye-hole for small or large fields, and a third fitted with tinted glass which screws on the other two for viewing the Sun.



Side View with Sun Cap.



Viewed from above. Lenses and Cap removed showing Occulting Shutters.

The uses for which this instrument may advantageously be employed are as follows: Occulting bright stars whilst examining the fainter ones around;* the planets whilst viewing their

* In using this instrument the observer must bear in mind that it takes an

satellites, especially those of *Jupiter* in transit; portions of the Moon, the details thus shown being sometimes very striking; Sun spots or their nuclei, no diagonal being needed if the observer screws up the shutters very close before looking through the telescope; searching for comets or examining nebulæ and clusters.*† As no clock is required for this instrument, and as all the shutters are at right angles to their neighbours, position angles can be very shrewdly calculated. To do this let the major star run along the edge of one or other shutter by turning the whole instrument on its axis, and bring a neighbouring shutter into the field. As the ordinary circular field is now reduced to an arc of 90° the Pos. Angle can much easier be guessed.

Due thanks must be accorded to Mr. Mason, the optician, who resides in my neighbourhood, for his great ingenuity and patience in perfecting many manufacturing details in this contrivance, and to Mr. Wray, jun., who especially designed the deep positive eye-pieces suitable to my requirements.

The Long Duration of Meteoric Radiant Points.‡ By W. F. Denning.

I have several times taken occasion to mention the very extended duration of a considerable number of the diverging centres of shooting stars, and the fact that there are successive recurrences of meteors from exactly the same points of the sky after short intervals of apparent quiescence. There are, however, grave mathematical difficulties to the view that such streams are physically associated. The fact of stationary radiants exhibiting visible activity during several months is a phenomenon so unaccountable and so utterly opposed to the approved theories as to the orbits of shooting stars, that it must receive a most crucial examination before it can be accepted. And the only applicable

appreciable time for the eye to recover the effect of the previous glare of the bright star; for that purpose it is well, I find, to keep the bright object some while behind a shutter before attempting to dismiss the field as barren. After a steady gaze a small star near α *Sagittæ* was observed Sept. 12 distinctly with the occulter, but *not visible* with my aperture (10 inches) whilst employing ordinary means. We judged its P.A. 180. Mr. Burnham wrote to the *Eng. Mech.* some weeks after to say he had discovered it with the great instrument he uses. He judged P.A. 180·5 with his micrometer.

* By loosening a small screw in the corresponding milled head of two of the shutters, they can be removed at once, and a blot or specially designed device easily substituted. This, it has been suggested, would be required for celestial photography in using the double printing process in conjunction with the occulter.

† It is worth a passing note that in using the occulter on clusters, the colours of particular stars are *much* better observed when neighbouring luminaries are absent. The contrast with and without the use of the shutter is very striking.

‡ For references to this question see also *Monthly Notices*, vol. xxxviii., pp. 111, 115, and 351.

and safe test is by observation prolonged to the utmost limits, and made as accurate as the conditions will possibly allow.

It must be conceded that a well-attested fact of observation, however hard to reconcile with known theories, ought on no account to be disregarded because of its nonconformity. Indeed, such facts should invariably be published, so that the evidence may be sifted and, if possible, the sources of difficulty removed. In a very modern and imperfectly developed branch like meteoric astronomy it is all the more necessary to mention discordances which may exercise an important bearing upon the theory of the subject. In this connection we might well remember the words of Humboldt,* which, though written some years ago, seem equally applicable to the present time:—"The progress of our knowledge respecting igneous meteors will be the more rapid the more impartially facts are separated from opinions, so that while carefully sifting or testing all particular facts on the one hand, we may not, on the other, fall into the error of rejecting as bad or uncertain observations whatever results we are not yet able to explain. It appears to me most important to separate physical relations from those geometrical and numerical relations which admit, generally speaking, of more certain and assured investigation."

It has been attempted to explain the evidence of long enduring meteor showers on the supposition of many successive though independent streams intersecting the Earth's orbit and displaying nearlythe same astronomical radiant points. The immense concourse of meteoric systems annually visible, the difficulties attending their precise observation, and the liability to obtain pseudoradiants by the accidental convergence of meteors not physically connected, have been mentioned as the probable origin of the observed anomalies. No one more freely than myself will admit the seemingly infinite number of meteor streams, and the practical difficulties in effecting their disassociation, and in accurately placing their radiant centres. But with experience these obstacles become less formidable; the observer gains confidence with greater aptitude, and is led by many circumstances to rely upon his work. He finds it expedient to connect the shower meteors by their individual features of resemblance. The apparent lengths of the paths, occurrence of streaks or trains, foreshortened tracks, &c., are to him details of the greatest significance in attributing the true radiant points, and cannot possibly be disregarded in reliable investigations of this kind. Observers soon become familiar with such appearances, and will not fail to recognise that, combined with the direction of motion (which in itself is often an insufficient guide), they afford the essential means of securing results of the most trustworthy and accurate character.

Consecutive meteoric displays having no natural connection, though issuing from the same region, must necessarily exhibit

* *Physical Description of the Heavens*, translated by Col. E. Sabine, 1866, p. 420.

small differences of position. They will disagree to some 5°, 7°, or more, and it will become evident from such palpable displacements that they are quite independent systems, unless indeed, similarly to the August *Perseids*, the radiant shifts amongst the fixed stars. But my observations absolutely prove that during several months the position of the radiant is unaltered; it adheres tenaciously to a stationary position. There are very slight differences of 1° or 2° between some of the determinations, but these are obviously due to the errors of observation which cannot be wholly eliminated from such determinations, though they are reduced to a minimum by great accuracy in recording individual meteors. In cases where the radiant adjoins a conspicuous star it is remarkable that wherever the point of divergence is first seen relatively to the star, so it remains during the whole interval of its sustenance. This could not possibly be the effect were the displays a mere chance grouping of streams perfectly dissassociated. I regard this peculiarity as a most significant one, and feel assured that it will stand the test of more extended and refined observation. Indeed, the more accurate and full the further investigation may be, the most concisely and indisputably will this fact of long duration become manifested.

It has been said that even if a radiant point were found persistent for several months by duplicate observations of meteors and other corroborative means, it could not be called one stream, because the particles must pursue different orbits. It would consist of a series of streams arranged in a peculiar manner, but not physically associated in a common orbit. This may or may not be the correct interpretation of the fact. In any case, it is obvious that multiple observations either of isolated fireballs or ordinary shooting stars will never influence the question at issue to any material extent, for such observations are usually accidental, and altogether too wild to affect an investigation in which great precision is of paramount importance. It must be admitted that it is a usual thing for the radiant points of fireballs, derived from a discussion of several observations, to show probable errors of 5°, 7°, or even 10°, whereas an isolated observer who closely watches the progress of a star shower may get its centre certainly within 2°, and very often within 1°. Even in cases where few meteors are noticed this is very practicable, especially should the radiant be low, and the meteors belong to the streak-leaving class. Occasionally, no doubt, a combination of the recorded flights of multiple-observed meteors results in accurate positions (the great fireball from *Taurus* on November 23, 1877,* may be referred to as an example), but it is an exception to meet with observations of the required precision.

* See *Observatory* for Jan., Feb., and March 1878, and *Astronomische Nachrichten*, No. 2566, where Von Niessl's computations of several fireballs from *Scorpio* (248°·3 − 20°·1) in June and July exhibit a remarkably close agreement.

It may also be mentioned that stationary meteors, though giving undeniable evidence of radiants, cannot be accepted as affording the precise indication of their positions. These so-called stationary meteors, registered in various catalogues, are usually much foreshortened tracks (perhaps $\frac{1}{4}°$ or $\frac{1}{2}°$ in length), which are very difficult to observe as regards exact direction, owing (especially in the instance of pretty bright meteors) to the dense offcome of sparks from the nucleus, or to the phosphorescence it generates as the result of concussion with the air. Luminosities of this appearance lying in the immediate wake of meteors will give an ill-defined, uncertain character to the slight motion that might otherwise be sharply perceptible. Moreover, such meteors often show a sinuous or curling motion, which is imparted to them in the act of penetrating atmospheric layers of different densities; * and this effect must obviously increase the difficulty in recording them with any approach to exactness. I have compared the positions of many alleged stationary meteors with the sharply defined radiant points to which they severally belonged, and the discordances are often as much as 5°.

Since the evidence of unusual permanency in radiant points first impressed itself on my notice I have given special attention to the circumstance, as it seemed a very important one, involving some mystery not yet explained in relation to these phenomena. It has been my aim, therefore, to register meteor paths with extreme care, and to reject all observations of doubtful character. I experienced a difficulty at first in retaining the *directions* with sufficient certainty while noting the *positions* of the beginning and end points relatively to adjacent stars. Doubt will often arise in the few seconds after the first impression, and while the observer is noting the place of appearance for the purpose of transferring the path to the chart, some means of aiding the memory in the exact retention of the directions seemed requisite. I found it of great assistance to project a perfectly straight wand, held at arm's length upon the track of each meteor as it appeared, then the eye readily assigned the fundamental points, and the path was accurately reproduced on the map. In cases where the meteor left a streak, or where the visible trajectory was slow, this proved a most effective means of obtaining exact positions, and the resulting radiants are reliable to within unusually small limits of error. I believe that diffused or elongated radiants, as such, do not really exist, but are due either to errors of observation or to nearly concentric streams of contemporary epoch.

Meteor systems of considerable inclination can only remain in visible activity for a very short time if they describe parabolic orbits, for the Earth's velocity will enable her to traverse a stream of five millions of miles in breadth in about three days.

* The sinuous or curving paths of certain meteoric particles may also be due, as Prof. Newton has suggested, to unsymmetrical forms. The resistance of the atmosphere upon such objects would probably cause a deviation from their original direction of flight.

Enormous breadth will originate longer duration, but the radiant point will show a displacement amongst the stars. Streams which encounter the Earth near the apex will, on the other hand, continue to be displayed for several weeks, according to the circumstances of the *rencontre*, but in every case there will be a gradual change of position in the direction of increasing longitude. *Perseids* from the August shower continue to fall during the twenty-six nights from July 25 to August 19, and their derivative radiant point advances from about R.A. 27° to 68° in that interval, as proved by my observations since 1867. There is, perhaps, no meteor shower whose duration is better ascertained than that of the noted August *Perseids*. The display first assumes a distinct and definite form on the night of July 25, when it furnishes about one meteor per hour. Thence it develops an intensity until August 10, after which it declines somewhat rapidly until August 19, when it appears to have become nearly exhausted, though, I believe, especially from my observations of the present year, that it is feebly sustained until August 22, when it gives about one meteor in three hours within the sphere of vision commanded by one observer. At the end of July the radiant point is close to χ *Persei*, on August 12–13 it has advanced to near B – C *Camelopardi*, and on August 19 is at 68° + 57°, or 22½° E. of its place on July 25. On August 22, 1884, I suspected very feeble traces of the shower from 77° + 56½°. I have drawn up the following Table from an analysis of all my observations of this prominent system:—

Date.	Horary No. of all Meteors.	Horary No. of Perseids.	Radiant Point of Perseids. α δ ° °
July 25	20	1	27 + 55
26	22	1	27 + 55
27	29	2	28 + 55
28	29	2	29 + 55
29	26	3	30 + 55
30	24	3	31 + 55
31	21	4	32 + 55
Aug. 1	18	5	33 + 56
2	18	5	34 + 56
3	20	6	35 + 56
4	21	6	36 + 56
5	22	7	38 + 57
6	24	8	39 + 57
7	27	10	40 + 57
8	34	16	42 + 57
9	48	32	43 + 57

Date.		Horary No. of all Meteors.	Horary No. of Perseids.	Radiant Point of Perseids. α δ ° °
Aug.	10	71	57	45 + 57
	11	44	29	47 + 57
	12	26	11	49 + 57
	13	23	7	51 + 57
	14	23	5	54 + 57
	15	22	4	56 + 57
	16	19	3	59 + 57
	17	18	2	62 + 57
	18	18	1	65 + 57
	19	18	1	68 + 57

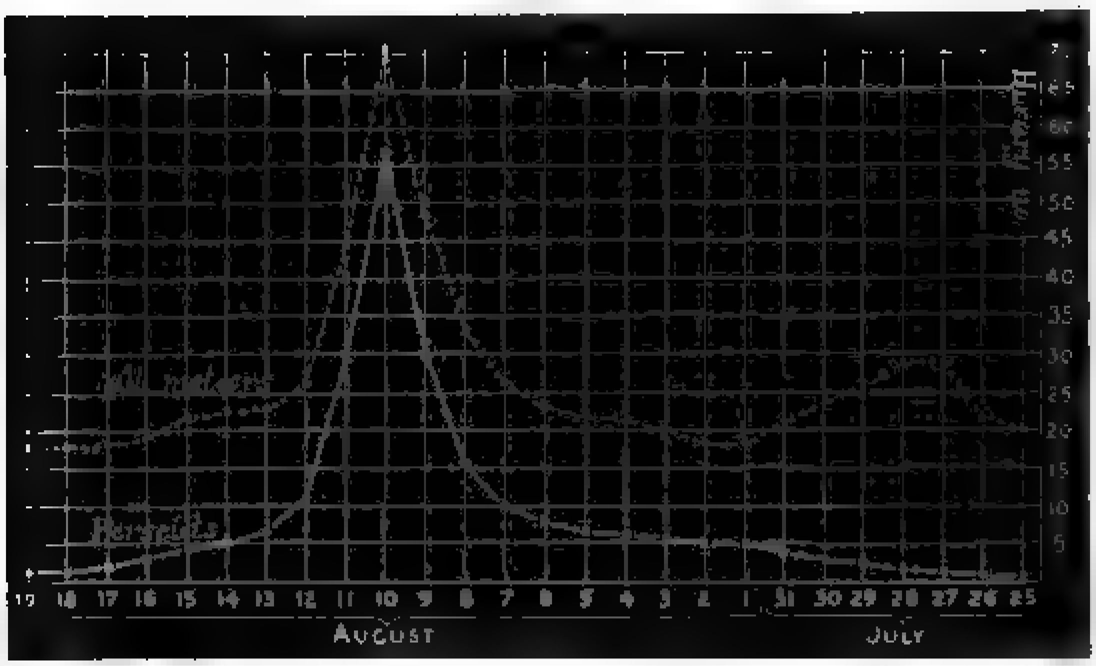


Fig. 1.—Diagram exhibiting horary numbers of all Meteors and Perseids. July 25–Aug. 19.

The horary number of all meteors on July 27–29 is very large, but the dates correspond to the July meteoric epoch, when the *Aquariads* furnish some eight or ten meteors per hour. The number of *Perseids* varies to some extent in different years owing to several circumstances, but I believe the average horary rate for this special stream, and the numbers inclusive of all contemporary showers, will be found near the truth. They are for one observer looking continuously towards the eastern heavens with very clear sky and in the absence of moonlight. At sea the horary numbers will usually be greater than those assigned; in towns, where mist and smoke interfere, and there is a good deal of artificial illumination of the atmosphere, the numbers will be less. Observations made from an open window, where the view is generally more restricted than out of doors,

will also have the effect of diminishing the horary rate of apparition.

The fact referred to as to the adherence of many showers to definite points during lengthy intervals is one which offers a singular contradiction to prevailing opinions. The peculiarity has been noticed by several observers, and if admitted, as it will most unquestionably have to be sooner or later, will open up some salient points for consideration, and perhaps materially alter our theoretical ideas as to the construction of meteor orbits as well as extend our views as to the effects of planetary perturbations upon these cosmical streams. It undoubtedly merits close attention, and it will be a most gratifying circumstance to find it subjected to a rigorous test by several competent observers. This might be effected without much difficulty by systematic observation undertaken during a few months in several successive years. The only conditions I would impose are: (1) That the observations must be continued for as lengthy a period as possible every clear night; (2) that all such paths as are utilised in the determination of radiants are to be accurately recorded; (3) that in each case the visible features be carefully considered, so that the individual meteors may be arranged in families according to their distinctive appearances, and thus the possibility of false radiants obviated; and (4) that the observations of not more than two successive nights be combined in ascertaining the positions. I make the latter condition because it has been asserted that many pseudo-radiants have resulted from the comparison of meteors registered during several weeks, and that were the observations kept separate and the positions determined for each night, or at most confined to two or three nights, the alleged long duration must disappear as the result of an erroneous method. I venture to assert that the very reverse of this will prove to be the case. The more limited the period for which the radiants are derived, and the more accurately they are fixed, the greater the number and more striking the character of the resulting coincidences. It is to be recommended on several grounds that the observations be grouped into intervals as short as is consistent with satisfactory reductions, and the observer should free himself of all bias as to positions he may have recognised on preceding nights, or which may have been determined by other observers at the same epoch. His main end should be the accurate recording of the directions of meteor flights and the detection of their sharply defined points of intersection. The only objection to the suggested short-period observations is the extreme feebleness of the great majority of showers,* which renders them difficult to identify in a single night, so that observers who limit

* A large proportion of streams give only 1 meteor in 3 or 4 hours. There are probably at least from 70 to 100 showers progressing every night, whereas the horary number of meteors does not usually exceed 15, so that the extreme sparseness of many of these systems is evident.

their reductions to this extent must necessarily watch during the entire night if their results are to be thoroughly full and trustworthy. It is true that very precise radiants are often derived from the intersection of only three or four meteor paths very exactly observed, but it is advisable to obtain as many tracks as possible to prevent the risk of pseudo-radiants. I have seen showers so attenuated as to afford only about one meteor in six hours, and there are a great number of more feeble character than this. Many streams also exist which are apparently of very intermittent nature. Two well-defined observations of a shower may be secured on dates separated by a few intermediate nights on which no conformable meteors are registered. This probably results from an irregular dispersion of the particles along the orbit. Were several observers watching the progress of the shower from widely distant stations it would doubtless appear continuous, and I support this opinion on the fact that in the case of certain radiants which have exhibited intervals of perfect rest one year, have in subsequent years shown great distinctness on the very nights of their former quiescence. Even during the same observation, when a lengthy one, I have sometimes noticed a similar peculiarity in a marked degree. In the first hour or two some half a dozen meteors have displayed sharp radiation and perfectly similar features, but during the middle hours of the watch no further indication of the stream has been remarked; towards the close of the observation, however, some further meteors have become visible from the same source. This proves that an observation extended for, say, three or four hours, is not always sufficient to definitely prove the non-existence of a stream whose visibility at the particular time may happen to be influenced by one of the temporary lulls to which they appear commonly subject.

This interrupted fall of meteors would manifestly often occur, especially in the instance of feeble systems giving, say, one meteor in three or four hours. The heavens abound in examples of such streams, and they are most densely congregated in the region following* the Earth's apex. We cannot assume that meteoric orbits consist of a perfectly regular dispersion of particles: in fact, the visible behaviour of these phenomena, so far as observations have enabled us to comprehend them, is conclusive as to the probable occurrence of sectional derangements (i.e. alternating richness and sparseness of distribution) that affect the local intensity and initiate that variable tendency which is so often the observed effect. Even in the case of exceptionally brilliant meteor storms we have it recorded that temporary lulls have occurred and imparted to them a somewhat

* The region of maximum richness is not *at* the apex, as is commonly understood, but some 40° *following* it (i.e. 130° from the Sun). The largest number of showers congregate here, and the fact is borne out by the relative horary rates of apparition of meteors which reach the highest figure at about 2^h or 3^h A.M.

intermittent character both in their development and decline. If, therefore, such conspicuous displays are sensibly affected in this manner, we can readily admit its operation in regard to minor streams whose chief peculiarities consist in their extreme tenuity of distribution and in the difficulties attendant upon their satisfactory identification.

It is not my intention to give an exhaustive analysis of the showers upon which I rely as demonstrating the long duration of certain radiants. I have selected six positions as examples; they are situated comparatively near together and will admit of conjunctive observation. It will be noticed in reference to each of these displays that they show a marvellous agreement in each of their successive positions. I subjoin tables of my own results and a supplementary list of other observations, together with the mean places derived from them separately and collectively.

The mean positions are as follows:

	Radiant. α δ	Apparent Duration.	Shower.	Positions averaged.
I.	$30^\circ\!\!.0 + 36^\circ\!\!.0$	July 16–Nov. 14	β Triangulids	23
II.	$46\cdot0 + 45\cdot6$	6– 30	α–β Perseids	31
III.	$61\cdot0 + 47\cdot7$	25– 27	μ Perseids	21
IV.	$61\cdot8 + 36\cdot8$	Aug. 2–Dec. 31	ϵ Perseids	26
V.	$76\cdot2 + 32\cdot6$	July 23– 27	ι Aurigids	21
VI.	$80\cdot2 + 22\cdot9$	Aug. 24–Jan. 15	ζ Taurids	25

I have conjoined the results of various observers with my own determination in order to show the degree and nature of the corroboration with regard to each shower. But it is upon my own observations that I rely in regard to the long duration of exactly identical radiants, for it must be sufficiently obvious to anyone, who considers the circumstances, that a miscellaneous collection of radiants even of the same shower will exhibit somewhat large discordances owing to difference of method and relative accuracy amongst the observers. On the other hand, a single observer who closely watches the fall of meteors and invariably pursues a uniform method, and whose sole aim is the detection of reliable and exact radiants, will obtain results in far better agreement than is found to exist between the positions given by different persons.

In the following Tables the abbreviations are H., Heis; S., Schmidt; S. Z., Schiaparelli and Zezioli; G. H., Greg and Herschel; A. S. H., A. S. Herschel; W., Weiss; T., Tupman; C., Corder; Sa., Sawyer; L., Lorenzoni; F., Felgel; M., Maggi; Dz., Denza; D., Denning (radiants observed); D.*, Denning (radiants derived from other observations).

I. *β Triangulids.*

α	δ		
°	°		
25 +	35	July 16–24	D*.
28	36	26–August 1	D.
30	37	29	D.
30	36	August 4	D.
30	35	July 15–September 14	D*.
30	36½	August 25	D.
30	38	21–31	D*.
30	36	September 14, 15, 21, and 25	D.
31	36	October 8	D.
31	37	13–19	D.
29	37	November 4–10	D.
29·6 +	36·3	July 16–November 10	

32 +	35	July 30	S. & Z.
33	33	August 5	L.
29	37	12–14	W.
30	40	August–September	C.
28	35	September 23	
36	35	September	G. H.
28	35	September 19–October 15	H.
27	36	October 8	Sa.
28	33	17–22	Sa.
32	34	22–31	C.
27	35	October–November	C.
33	40	November 3–14	Dz.
30·3 +	35·7	July 30–November 14	

30°·0 + 36°·0 mean of 23.

II. *α–β Perseids.*

α	δ		
°	°		
47 +	45	July 6–17	D.
48	43	23–25	D.
41	40	25–31 and August 13	D*.
50	47	August 6–12	D*.
44	46	2–11	D*.
[illegible]	47	6–12	D*.
46	45	3–16	D.
46	45	19–21	D.
46	47	21–23	D.
45	47	21–31	D*.
44	43	24–September 14	D*.

α	δ		
47°	+45°	September 4–16	D.
45	46	October 20	D.
46	46	October 31–November 4	D.
48	43	November 12–14	D.
46·1	+45·0	July 6–November 14	

α	δ		
50	+48	August 3–12	S.
47½	48	6	T.
42	48	7	S. Z.
48	49	10	M.
47	43	11	S. Z.
40	45	August	H.
48	41	September 5	T.
45	50	August 29	T.
45	50	September	C.
46	48	September 21	C.
45	40	1–13	H.
44	46	October	C.
47	47	October	C.
46	44	October 16–November 30	H.
42	43	November 10	Se.
50	49	November	G. H.
45·8	+46·2	August 3–November 30	

$46°·0 + 45°·6$ mean of 31.

III. *μ Perseids.*

α	δ		
63°	+50°	July 25–31	D*.
61	48	August 3–16	D.
61	48	6–12	D*.
61	50	21–23	D.
60	50	21–31	D*.
63	46	September 1–10	D*.
61	48	14–25	D.
62	46	26–30	D*.
61	47	October 2–18	D.
62	47	20–31	D*.
61	49	28–November 13	D.
59	48	November 12–13	D.
61·3	+48·1	July 25–November 13	

α	δ		
56°	+ 47°	August 3–11	S.
61	43	10	P.
63	46	10	J.
60	51	11	A. S. H.
62	48	August	C.
68	46	August 3–30	G. H.
62	46	29	H.
55	45	October 2–November 23	H.
59	53	November 15–27	H.
60·7	+ 47·2	August 3–November 27	

61°·0 + 47°·7 mean of 21.

IV. *ε Perseids.*

α	δ		
59°	+ 39°	August 2–11	D*.
61	39	6–12	D*.
62	35	21–31	D.
62	37	25	D.
67	35	25–September 14	D*.
63	38	September 1–10	D*.
61	36	4–16	D.
60	37	5–12	D*.
61	36	6	D.
63	34	26–30	D*.
62	37	October 20–November 12	D*.
62	36	29– 13	D.
60	34	November 4–12	D.
62	38	1–7	D*.
62	34	12–13	D.
60	37	25–December 13	D.
62	38	25– 31	D*.
62	38	December 1–8	D*.
61·7	+ 36·6	August 2–December 31	

61	+ 39	August 10	
64	39	11–26	H.
60	32	September 6	S. Z.
66	40	7–15	T.
[illegible]	37	1–30	H.
[illegible]	37	November 6	A. S. H.
61	42	9	S. Z.
66	34	December 3–11	H.
61·9	+ 37·5	August 10–December 11	

61°·8 + 36°·8 mean of 26.

V. ι *Aurigids.*

α	δ		
75°	+31°	July 23	D.
74	33	August 6–12	D*.
75	33	27	D.
76	32	September 14–25	D.
76	34	26–30	D*.
77	31	October 8	D.
78	33	12–31	D*.
76	33	14–15	D.
78	37	29–November 13	D*.
77	32	November 7	D.
76½	33	12–13	D.
85	33	20	D.
77	33	20–30	D*.
78	32	December 9–12	D*.
76	34	21–27	D*.
77·0	+32·9	July 23–December 27	
70	+31	August 29	T.
70	32	September	S.
80	30	September	C.
77	37	October 8	T.
77	30	13	T.
71	31	10–27	S.
74·2	+31·8	August 29–October 27	

76°·2 + 32°·6 mean of 21.

VI. ζ *Taurids.*

α	δ		
78°	+23°	August 24–September 14	D*.
81	23	September 5–12	D*.
80	25	14–25	D.
80	21	October 2–November 13	D.
81	23	12–31	D*.
80	24	November 12–14	D.
82	24	20–30	D*.
80	23	22–December 8	D.
78	24	27	D.
80	25	29–December 8	D.
81	23	December 1–8	D*.
83	23	7–13	D.
80	23	January 1–15	D*.
80·3	+23·4	August 24–January 15	

α	δ		
°	°		
78	+ 23	August 29	T.
78	23	September 8–10	T.
80	19	October 13	S. Z.
78	25½	21	S. Z.
80	22	November 20–December 9	Sa.
81	21	26–29	Sa.
81	23	21–28	Sa.
80	20	December 4–12	G. H.
82	23	7–12	Sa.
78	23	7–13	C.
83	23	11	F.
81	22	27	A. S. H.
80·0	+ 22·3	August 29–December 27	

80°·2 + 22°·9 mean of 25.

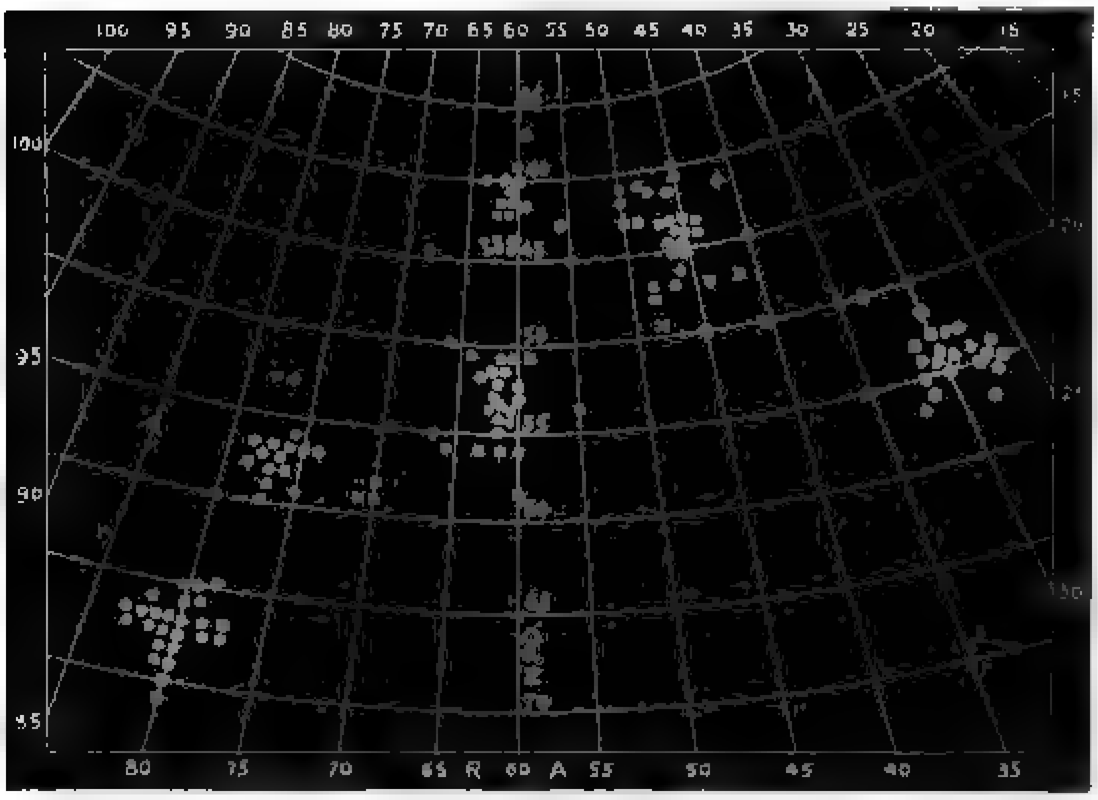


FIG. 2.—Individual positions of showers belonging to long-enduring radiants.

I. A remarkably well-defined radiant point frequently appearing during the five months, July to December. The position is about 1½° N. of *β Trianguli*. The conformable meteors are small; fireballs rarely come in this shower. It has been most fully observed during July–August, owing to the circumstance that at the epochs of the July and August meteors a large number of observers have explored this special quarter of the sky. In October and November the south-westerly position of

the shower late in the night, with its high altitude, would render it more difficult of detection unless by observation in the early evening. Even assuming an equal activity of the radiant in autumn as in the summer, it would have attracted considerably less notice from the causes assigned. The place of divergence, as I have repeatedly observed it in each of the five months of its apparent duration, has been singularly sharp and persistent at the point about $30°+36°$. It formed rich displays on July 29, 1879, August 4, and October 8, 1877, and August 25, 1884. My own determinations of the radiant are all nearly coincident. This is hardly applicable to the series of positions derived by other observers, but the comparison of such results by widely different observers must certainly introduce considerable discordances. Even in cases where a prominent periodical shower has been the one observed, a combination of the values for the radiant as given by various astronomers will disclose positions

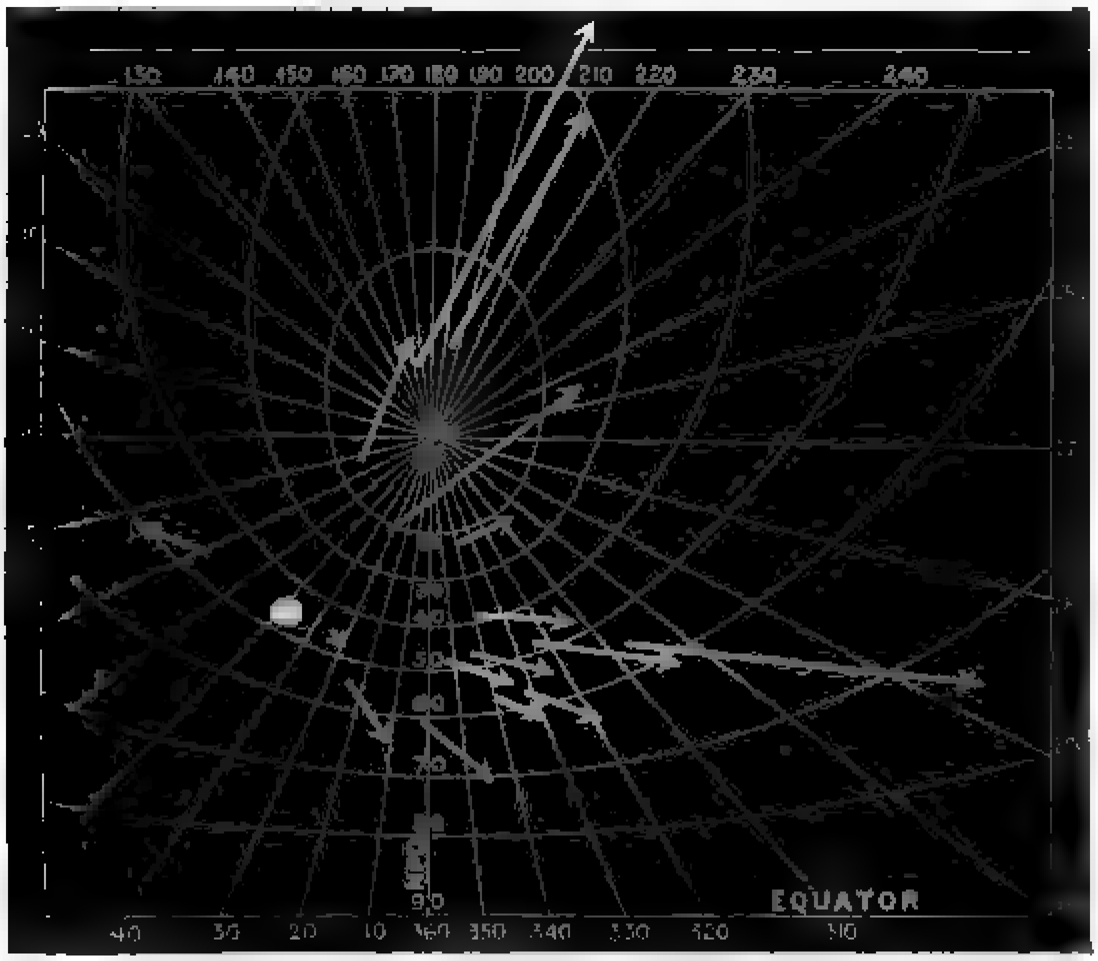


Fig. 3.—Meteor shower from α–β Persei (48 +43°) July 23-25, 1884 (W. F. Denning).

differing to the extent of 5° or more. The mean centre for this shower near *β Trianguli* is, however, very accordant as regards my own results and those of other observers, and I believe the individual determinations are all well within the probable errors of observation. With respect to the averaging of bordering radiants and the deduction of mean positions, I would remark that the work requires great caution and discrimination, owing

to the crowding together of streams perhaps distinct in themselves though nearly similar in some of their elements.

II. The mean position falls almost exactly between α and β *Persei*. My several estimates for this radiant between July and November are nearly identical. I have seen it on many other dates in addition to those mentioned in the list, though not with satisfactory fulness, and as far as my observations enable me to judge, the shower is very nearly continuous as well as stationary during the five months named. In July and August it is particularly rich, and I have often observed its brilliant streak-leaving meteors with great interest. On July 23–25, 1884, it formed a rich shower, and furnished a close agreement with the radiant and date of Messier's Comet of 1764, but the accordance is very doubtful as regards the inference of physical connection. This radiant has been more frequently observed in July–August, because of the great number of observations annually made at this season, and it is situated only 12° S. of the *Perseids* of August 10. Mr. Corder has seen it in striking activity in October and November, and it is marvellous how the very same point of radiation is renewed again and again. This is the significant fact with respect to these α–β *Perseids* and other long-continued showers, that the successive points of departure are very nearly coincident, while the immediately adjacent spaces are devoid of such displays. This centre in *Perseus* is also the seat of activity in January, according to the observations of Heis and Schiaparelli and Zezioli.

III. Close to μ *Persei* and 5° E of δ. This shower has not been so numerously observed as the preceding one, but it exhibits the same remarkable accordance in its successive positions. It has been most satisfactorily distinguished in the months of August and September, when this especial region has been the centre of a large amount of observation. In conjunction with the showers near $\alpha-\beta$ and ϵ *Persei* it forms a triangle, and it is very singular that these points are manifested again and again as the very exact centres of meteor showers. Occasionally fireballs are emergent from this stream at μ *Persei*; the great meteor of August 11, 1876, had a radiant at $60°+51$ (A. S. Herschel). The corroborative radiants adduced from the catalogues of other observers are not so nearly coincident as the summary of my own positions, though the mean shows little departure. This shower, though comparatively near the $\alpha-\beta$ and ϵ *Perseids*, is hardly capable of confusion with them unless the meteors are observed inaccurately, and without due regard to their apparent directions. In cases like this, where it is desirable to separate bordering showers, it becomes more than ever necessary to register the individual paths with the utmost attainable precision, because there is often very little distinction in the visible aspects of meteors proceeding from regions so nearly adjacent.

IV. 5° S.E. of ϵ *Persei*. The radiant is persistent during

the last five months of the year. It forms a very noteworthy shower during the first half of September, especially about the 6–8, and again on about November 4. At these epochs it supplies fireballs of the largest dimensions.* The great bolide of November 6, 1869, 6^h 50^m, observed by myself and many others, had a radiant point at $62°+37$ (A. S. Herschel).† The doubly observed meteor of August 10, 1872, had a radiant at $61°+39°$. This shower is very well marked during the whole period of its duration, and shows a sharply-defined radiant point. In August and September its meteors are very swift, and bright streaks are their characteristic feature. The supplementary table of radiants is not very consistent in the individual agreements, though the mean is almost exactly coincident with my own result. It is rather doubtful whether the position at $61°+42°$, Nov. 9, by S. and Z., belongs to this shower or to the following one near *μ Persei.*

V. This radiant is some 2° following a line connecting *ι Aurigæ* and *β Tauri*, and 3° E. of the former star. The position is very sharply defined, and it represents the focus of divergence of numbers of shooting stars during the last half of the year. The corroboration by other observers is excellent as regards the mean, but the separate values are not as accordant as might be expected, though they undoubtedly represent the same radiant point. It is satisfactory to note, however, that Tupman's position at $77°+30°$, Oct. 13, which is the only one falling really very near the true centre, was specially designated as "accurate" by its careful observer. The pair of positions by Schmidt in September and October close to *ι Aurigæ* are proved both by my own and Tupman's results to be 5° too far W. On the other hand, the position by the latter observer for Aug. 29 is equally discordant in the same direction, and the radiant I saw on Nov. 20 is some 7° E. There are errors in several of the other values, which are obviously too far N., and that these errors are real and capable of being thus assigned I have assured myself by a large number of observations and reductions as accurate and complete as it is possible for me to make them. The radiant is strikingly permanent, and further views of it are much required during its earlier displays, especially in August. The shower is very distinctly visible on about the 27–29th of that month, but it can only be well distinguished in the morning hours, owing to the low position of the radiant in the earlier hours of the night. It occasionally supplies fireballs, for the great meteor, estimated as of equal brightness with the full Moon, seen in the South of France on Nov. 11, 1864, in the evening twilight, had a radiant at $83°+35°$ (± 10). A pair of fireballs observed near midnight on Oct. 8, 1877, also very probably belonged to this stream. Heis appears to have noticed something of it in the months of October–November; for he gives a position at $83°+28°$ (47

* See *Observatory*, September 1882, p. 262–5.

† *Proceedings of the British Meteorological Society*, June 15, 1870.

meteors), which is evidently a combination-radiant resulting from a confusion of the paths from this shower near *ι Aurigæ—β Tauri*, and the bordering one, 10° S., near *ζ Tauri*, which would obviously indicate radiation from the place assigned by Heis.

VI. The mean centre is 3° N.W. of *ζ Tauri*. A succession of showers have their origin here during the last five months of the year, and there are continued traces of radiation from the same point in January. It has been principally distinguished, however, between Nov. 20 and Dec. 13, when it constitutes a display of great distinctness, and the prominent character of the shower has been admitted by several observers. I detected this stream in unusual activity on Dec 6, 1876, and it has re-appeared annually since that time. In the case of this radiant the supplementary positions adduced from the catalogues of other observers show an equal consistency with my own, and there is no doubt as to the prolonged duration. More observations will be very useful, however, in September and October. Tupman found it a very active shower on Sept. 8–10, 1869, and it would doubtless have commanded more observers at this early period but for the fact of the late rising of the radiant point, which necessitates morning observations. I do not think Schmidt's shower at 79° + 13°, or Tupman's at 75° + 15°, Sept. 22, and 77° + 10°, Nov. 10–11, or several positions of my own at nearly the same places are to be regarded as connected with these *ζ Taurids*, as they are fully 10° distant. And it is not advisable to include positions differing to such an extent, as they are evidently distinct systems which must, if combined with systems really associated, only introduce a false mean. Fireballs of the largest type sometimes emerge from this radiant. The fine meteors of Dec. 8, 1861, and Dec. 27, 1864, gave positions at 91° + 18° (±10°) and 81° + 22° (±15°) respectively. I saw a fireball from this stream on Dec. 6, 1883.

In addition to these selected examples there are many other instances of abnormal duration in radiants retaining a fixed place amongst the constellations. I subjoin a list of some of the most prominent and best observed of these, as they will doubtless be often re-observed in future years:

Ref. No.	α °	δ °			
7	6·6	+ 12·7	June	to	September.
8	7·2	+ 52·1	July	„	November.
9	7·7	+ 35·9	July 21	„	November 13.
10	31·2	+ 17·8	July	„	November.
11	43·9	+ 25·1	August 3	„	November 13.
12	69·5	+ 65·2	July 25	„	December 8.
13	70·0	+ 50·7	August 21	„	November 4.
14	76·2	+ 44·8	August 4	„	December 14.
15	78·0	+ 75·7	August	„	October.

Ref. No.	α °	δ °			
16	9·1	+55·8	August 6	to	December 31.
17	97·4	+44·3	August 6	„	December 8.
18	106·1	+11·9	Sept. 15	„	January.
19	108·5	+24·2	September	„	December
20	132·3	+46·9	September	„	February.
21	132·5	+20·8	October 11	„	February 16.
22	145·4	+ 3·9	November	„	April.
23	181·1	+34·7	October 16	„	April 12.
24	206·1	− 7·6	January	„	May.
25	226·6	− 5·4	January	„	May.
26	268·6	+23·4	March	„	September.
27	285·9	−13·0	Feb. 10	„	August.
28	290·6	+69·7	July 26	„	October 31.
29	315·5	+60·0	April 19	„	November 15.
30	332·2	+36·1	March 17	„	September.
31	332·8	+48·6	June	„	October.
32	334·8	+27·2	May	„	September 14.

Stationary, long-continued radiants appear to be a general feature of attenuated showers, though I have singled out some equally well-defined displays of very brief, fugitive character, which are doubtless of similar type to the *Quadrantids* of Jan. 2 and *Lyrids* of April 20. There are many varieties apparent amongst these phenomena, not only in the individual meteors, but in their congregated streams. The permanent showers appear to occur irrespective of inclination. The first decided intimation of their presence is usually recognised when the radiants are near the Earth's apex. At such times they furnish very swift streak-leaving meteors. Later on they lose the capacity to generate streaks, and ultimately are transformed into the slow train-bearing meteors whose radiants cluster in regions far removed from the Earth's direction of motion. Yet during the whole time of the display, and while the individual meteors are thus visibly affected by the change, progressing from night to night in the positions of their divergent points relatively to the Earth's apex, their radiants remain immovable; and the fact is conclusively proved, not by approximate accordances, but by absolute coincidence in these points as observed with great care and precision.

Since 1877 I have generally confined my radiants to short periods, though in some cases have been compelled to associate many showers whose positions were almost identical. Thus, the *Andromedes*, which maintain an apparently continuous display between July and December, were found to be so frequently visible that they gave about forty separate radiants, all agreeing

fairly well. To clearly exhibit my meaning, I add a summary of my position for this stream during the months of July and August as resulting from my own observations. Had I dissected

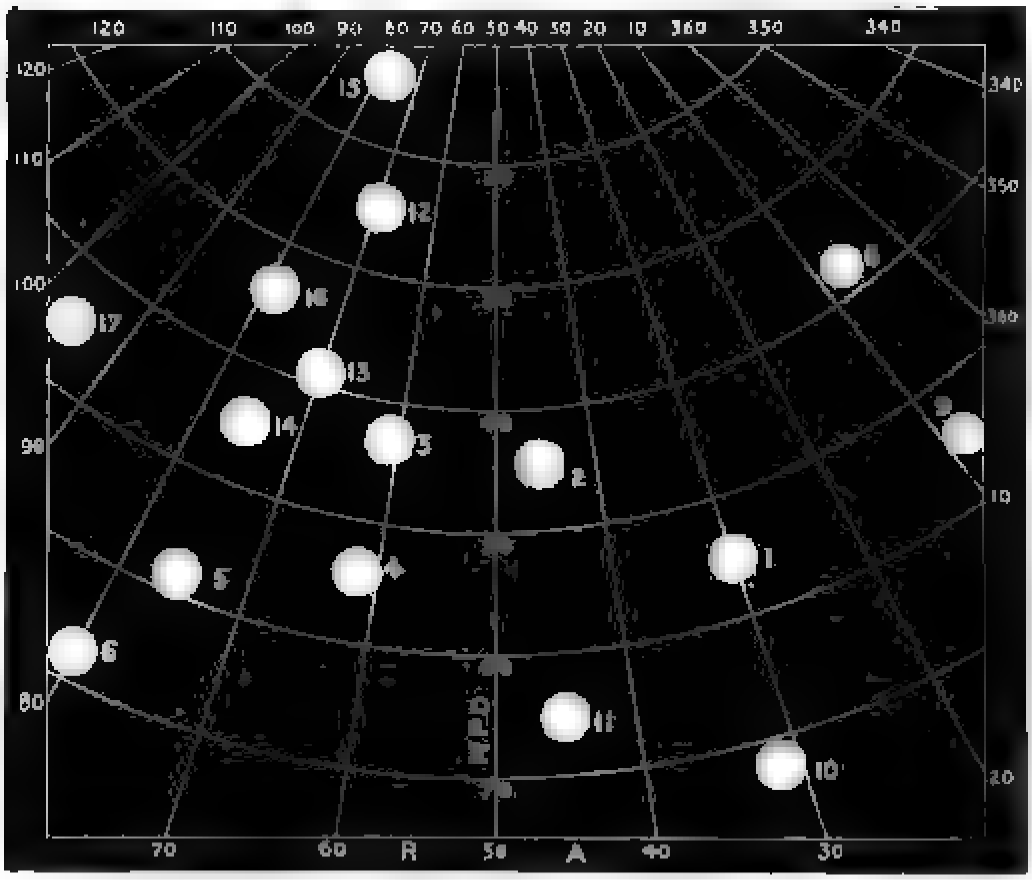


FIG. 4.—Positions of 16 long-enduring radiant points.

my reductions of meteors recorded by foreign astronomers, the number of positions would be greatly augmented :—

	α δ		α δ
July 7	$4^\circ + 35^\circ$	August 4	$9^\circ + 34^\circ$
11	5 + 35	7	8 + 38
12	7 + 37	10	6 + 37
16	5 + 35	11	8 + 38
26	3 + 35	12	10 + 38
27	6 + 34	16	10 + 37
28	7 + 36	20	3 + 35
29	7 + 37	21	5 + 37
30	6 + 35		

Mean of 17 (July–August) = $6^\circ{\cdot}4 + 36^\circ{\cdot}1$.

Analysing the six special showers near β *Trianguli*, α–β, μ, and ϵ *Persei*, ι *Aurigæ*, and ζ *Tauri*, I find a numerous series of positions showing even closer agreements than in the case of these *Andromedes*. The radiant at $30^\circ + 36^\circ$ I have seen with great cer-

tainty and definiteness of radiation on twenty-one different nights, and it always recurs from very nearly the same point. Such trivial differences as are apparent are solely due to unavoidable errors of observation. My best determinations more nearly coincide than those which I regard as less certain. These showers appear to be continuous as well as stationary, for the accumulation of new observations has the tendency to fill up the epochs of their apparent quiescence.

In the instance of very feeble showers it is dangerous to watch for them particularly, as a few meteors will certainly be recorded with directions conforming to their radiant points, though really belonging to other systems. I believe, however, that an observer of experience, who is accustomed to grouping the showers according to their traits of appearance, will not be likely to introduce errors of this kind, though it is always safest to register the meteors in the ordinary manner, and then deduce the most certain radiants, without regard to expected showers or to positions formerly assigned by other observers on the same dates. This is the only method of obtaining perfectly independent and reliable centres eligible for comparison with the similar investigations of preceding years.

I have mentioned the fact of this seeming continuity of meteor streams for several reasons. Though frequent revivals of identical radiants may not essentially mean a prolonged exhibition of the same meteor orbit (it is impossible to comprehend how it can be interpreted in that way with due regard to prevailing ideas as to the forms of meteo-cometic orbits), it yet strikingly suggests some curious arrangement which it will be very interesting and important to further investigate. A law may be discovered affecting the construction of these streams, or some influence recognised, as the result of such inquiries, which may enable us to adopt the thesis that these alternating showers are connected in some way, and not a mere effect of great numbers causing their re-apparitions from the same points. If this explanation were applied, there would be discordances, furnishing a direct negative to the concise and exact character of the radiation which I have in many well-defined instances recognised for several months. And I apprehend there is a meaning attaching to these stationary radiants which we should endeavour to elucidate rather than avoid by apparently feasible explanations, and which, though not altering the fact, must operate to check the renewed observation and analysis by which alone the difficulty admits of settlement.

Another point that has led me into this question is, that we now require a new general catalogue of meteor showers, but it is impossible to satisfactorily arrange the observations of many different observers until this matter affecting the visible duration is finally disposed of. Mr. Greg's "General Comparative Table of Radiant Points and Durations of Meteor Showers visible in the Northern Hemisphere" was published in the *British Association*

Report for 1876, and consisted of 206 mean positions, resulting from a discussion of 850 radiants and sub-radiants founded on some 15,000 shooting stars. Now, since this catalogue appeared we have many additional lists of observed meteor showers by Heis, Konkoly, Weiss, Corder, Sawyer, myself, and others, so that in the aggregate there are more than 2,100 radiants resulting from the projected paths of upwards of 62,000 meteors! Many of these radiants undoubtedly consist of duplicate observations of identical showers, and I do not believe that the total number of well-defined streams would exceed 350 by a careful comparison and averaging of the positions on the method adopted by Mr. Greg. It is, however, evident that a great necessity exists for a new and thoroughly reliable reference catalogue in which all the hitherto published lists are suitably represented; and it had been my intention to compile such a work, but the anomalies as to the durations of certain systems confronted me with such force that I was led to abandon the undertaking for the present. The question is, are these radiants to be grouped into periods of several months, or are they to be limited to as many days? If the former, then the number of showers understood as separate will obviously be greatly lessened; if the latter, the total will be correspondingly increased. Are we, say, in the instance of the display near μ *Andromedæ*, to dissect it into thirty independent systems, averaging a duration of five days each, or must we present it as one nearly continuous stream covering five months? While the indubitable evidence of our eyes favours the latter proposition, the equally conclusive teachings of the theory of the subject (which it was thought would so readily accommodate the visible phenomena of meteors, but which has unquestionably given rise to a too hasty generalisation) can only directly oppose such a view.

There is no doubt that this question of persistency is a very complicated one, and I cannot see how it is practical to dissociate the displays into short periods. It will not do to force the observations into a groove with which they do not harmonise. Even if all the results which have accumulated up to the present time were absolutely abandoned as too uncertain and discordant for safe acceptance, and were the individual meteor paths in all available catalogues carefully re-examined and projected with a view to determine the definite radiants for each night separately, the conditions of the case would not be improved. There would be a general blending of exact and wild observations to which would be given equivalent weight. There would be the impossibility to consider those most suggestive details as to the visible aspect of the meteors, such as the length of path as affected by the altitude of the radiant above the observer's horizon, occurrence of streaks or trains, slow or swift motions, all depending on the position of the radiant relatively to the Earth's apex, which must conspire to destroy that very accuracy which would be the main, if not indeed the sole, object of such an investigation. Could a work of this magnitude be conducted

on favourable lines, the results must still exhibit the remarkable permanency of many showers and the difficulty of separating them. For my own part I am firmly persuaded that radiant points, to be thoroughly precise, should be determined by the actual observer of the meteors, who must feel his way very cautiously and with a due regard to all the circumstances which alone can lead him to trustworthy results. The storing up of many thousands of unreduced meteor flights is, therefore, to be deplored. The accurate and safe discussion of such materials is questionable; it could only have been effected at the time by those employed in recording them. I have myself projected some 19,000 meteors in the catalogues of various continental astronomers, and though the results generally corroborate what I have myself seen, I cannot feel nearly the same confidence in them. Look at the tables of radiants by Tupman, Sawyer, and others, who reduced their own observations while fresh in the memory, and there will be found a marvellous number of accurate positions (I say this advisedly after many opportunities of fully testing them), though in some instances they rest on comparatively slender materials. In some other catalogues the most obvious blunders have been committed, and the result is many fictitious radiants. Cases exist in which meteors of 10°, 15°, or 20° in length are assigned to showers a very short distance in the backward prolongation of flight, which is utterly inconsistent with the palpable effects of perspective in apparently contracting the paths close to their originative point. It is most essential that before an observer undertakes the reduction of such observations, he should watch the divergence of meteors from prominent showers like the *Perseids* and *Leonids*, and form some practical idea as to the foreshortening of the tracks which fringe the radiant; but it is not my aim to refer to special misconceptions in a department which does not admit of absolute accuracy, and exhibits anomalies that are even more difficult to explain than they have been to discover.

The prolonged duration of meteor showers gives rise to a curious antagonism of theory and observation which, I trust, will now receive further investigation. The data upon which the discordance rests is, I feel convinced, thoroughly reliable, and renewed observation can only tend to endorse the result arrived at. I am unable to offer any hypothesis in explanation; the matter presents itself as one of great difficulty, but is yet so singularly well marked that it will bear the most critical examination. Though meteor streams like the *Quadrantids* and *Lyrids* are marvellously transient in their visible aspect, the shifting radiant of the *Perseids* shows a more extended, though very distinct, duration of twenty-six days, and the number of systems far exceeding this period are extremely numerous. It will be advisable to select a few of these showers as examples, and rigorously investigate them. Some important peculiarities of arrangement may regulate such long-enduring streams, and we

may find a certain physical association existing among them notwithstanding their dissimilarity of orbit. The most significant fact in connection with this subject is that certain sharply-defined points exhibit a numerous retinue of showers, while the spaces immediately adjacent are comparatively barren of such displays. The radiant points coincide at particular centres, to the marked exclusion of closely-bordering regions. To re-observe with the utmost fulness and accuracy the evidence which the sky affords, leading to this remarkable conclusion, and to discover, if possible, the *meaning* of this singular persistency of showers, will be the important aim of future observations; it may clear away a difficulty from observers, and perhaps enlarge our views as to the visible character of meteor systems. The uninterrupted appearance of shooting-stars in the nocturnal sky offers the ready means of attacking the problem anew and removing any doubts which may still exist as to the stationary, long-enduring aspect of many showers, which must, indeed, remain an indelible effect of all full and trustworthy observation.

Bristol: 1884, *October*.

Observations of Comets Pons-Brooks and Ross. By A. B. Biggs.

(*Communicated by the Secretaries.*)

(*By triangular-bar Micrometer. Dark field.*)

Date.	Mean Time. (Launceston.)	Diff. R.A. Comet from Star.	Diff. Decl. Comet from Star.	Name of Star.	Hour Angle. (Approx.)
1884.	h m	m s	′ ″		h m
Jan. 26	9 52 0	+ 1 33·25	+36 58·6	7 Ceti	
	9 56 0	+ 1 36	+37 9·4	,,	
29	8 52 0	− 2 51·5	−22 30	106 Lacaille	5 2 W.
	8 57 0	− 2 49·7	−21 59	,,	5 8
	9 4 10	− 2 47·5	−21 0·8	,,	5 15
Feb. 11	8 45 23	− 0 19·3	+28 59	305 Lacaille	5 9½
	8 55 21	− 0 18·3	+29 36	,,	5 19½
23	10 10 0	+ 3 15·7	+28 56	γ Phœnicis	6 54½
	10 16 45	+ 3 16·5	+29 19·6	,,	7 0
Mar. 2	9 53 0	− 3 30	− 12 57	542 Lacaille	7 0
11	8 17 30	+ 8 32·7	−17 41	588 ,,	5 35
12	7 35 30	−10 5·5	+ 9 27	693 ,,	4 53
13	8 13 0	− 7 15·5	+39 57	,,	5 34*
	8 28 0	− 7 18·5	+40 43·5	,,	5 53¼

Date.		Mean Time. (Launceston.)	Diff. R.A. Comet from Star.	Diff. Decl.	Name of Star.	Hour Angle. (Approx.)
1884.		h m	m s	′ ″		h m
Apr.	3	8 48 45	− 0 4	− 11 36	989 Lacaille	6 38
		8 57 45	− 0 3·3	− 10 1	„	6 47
	4	8 50 20	+ 3 33	+ 10 15	„	6 29
		8 59 20	+ 3 45·5	+ 10 34	„	6 48
			Comet "Ross."			
Feb.	1	9 15 0	+ 0 14·7	+ 19 43	9623 Lacaille	6 14
		9 25 0	+ 0 17	+ 18 24	„	6 24

A very hazy object; nebulous; measures very difficult; no definite point. The only opportunity afforded for obtaining measures.

In all the above measures, different refraction and the comet's proper motion are not reckoned for.

Launceston, Tasmania: 1884.

Ephemeris for Finding the Positions of the Satellites of Uranus, 1885. By A. Marth.

The angle of position P of the minor axes, the major and minor semi-axes *a* and *b* of the apparent ellipses described by the satellites, the longitudes *u*—U of the satellites reckoned in their orbits from the points which are in superior conjunction with the planet's centre and the planeto-centric latitude of the Earth above the assumed plane of the orbits, are approximately the following:

Greenw. noon		P.	Ariel. a_1	b_1	u_1-U	Diff.	Umbriel. a_2	b_2	u_2-U	Diff.
1885.		°	″	″	°	°	″	″	°	°
Jan.	13	285·45	14·75	+4·29	114·70	1428·46	20·54	+5·97	134·01	868·75
	23	·46	14·87	4·30	103·16	·44	20·72	5·99	282·76	·72
Feb.	2	·47	14·99	4·28	91·60	·41	20·89	5·97	71·48	·70
	12	·48	15·09	4·24	80·01	·38	21·03	5·91	220·18	·69
	22	·50	15·18	4·18	68·39	·35	21·14	5·83	8·87	·66
Mar.	4	·51	15·24	4·10	56·74	·33	21·23	5·71	157·53	·65
	14	·53	15·27	4·00	45·07	·30	21·27	5·58	306·18	·63
	24	285·54	15·28	+3·89	33·37	·27	21·28	+5·43	94·81	·61
Apr.	3	·55	15·26	3·78	21·64	·26	21·26	5·27	243·42	·61
	13	·56	15·21	3·67	9·90	·24	21·19	5·11	32·03	·60
	23	·57	15·14	3·56	358·14	·23	21·10	4·96	180·63	·60
May	3	·57	15·05	3·46	346·37	·23	20·97	4·82	329·23	·60
	13	·57	14·95	3·37	334·60	·22	20·82	4·70	117·83	·60
	23	·58	14·83	3·31	322·82	1428·22	20·66	4·61	266·43	868·61
June	2	285·57	4·70	+3·26	311·04		20·48	+4·54	55·04	

			Titania.				*Oberon.*			
	Lat. of Earth.	a_3	b_3	u_3-U	Diff.	a_4	b_4	u_4-U	Diff.
1885	°	"	"	°	°	"	"	°	°
Jan. 13	+16·90	33·70	+9·79	207·38	413·53	45·06	+13·10	35·30	267·40
23	16·79	33·99	9·82	260·91	·51	45·45	13·13	302·70	·38
Feb. 2	16·60	34·26	9·79	314·42	·50	45·81	13·09	210·08	·37
12	16·33	34·49	9·70	7·92	·48	46·13	12·97	117·45	·36
22	16·00	34·68	9·56	61·40	·47	46·38	12·78	24·81	·34
Mar. 4	15·61	34·82	9·37	114·87	·46	46·56	12·53	292·15	·34
14	15·20	34·89	9·15	168·33	·45	46·66	12·23	199·49	·34
24	+14·77	34·91	8·90	221·78	·45	46·68	11·90	106·83	·33
Apr. 3	14·35	34·86	8·64	275·23	·45	46·62	11·55	14·16	·33
13	13·95	34·76	8·38	328·68	·44	46·48	11·20	281·49	·33
23	13·59	34·60	8·13	22·12	·45	46·27	10·87	188·82	·34
May 3	13·29	34·40	7·90	75·57	·46	46·00	10·57	96·16	·35
13	13·05	34·15	7·71	129·03	·46	45·67	10·31	3·51	·36
23	12·89	33·88	7·56	182·49	413·48	45·31	10·11	270·87	267·37
June 2	+12·82	33·59	+7·45	235·97		44·92	+9·97	178·24	

These values are to be interpolated for the times for which the positions of the satellites are required. The position-angles p and distances s are then to be found by means of the formulæ:

$$s \sin (p-P) = a \sin (u-U)$$
$$s \cos (p-P) = b \cos (u-U)$$

The satellites move in the direction of *in*creasing position-angles, and will be at their greatest elongations ("N" in posit. P+90° and "*s*" in posit. P−90°), and at their superior and inferior conjunctions with the centre of the planet about the following Greenwich mean times:

Ariel.

1885.	N.	S.		N.	S.		N.	S.
	d h	d h		d h	d h		d h	d h
Jan.	12 19·9	14 2·1	Mar.	1 17·1	2 23·3	Apr.	18 14·4	19 20·7
	15 8·3	16 14·6		4 5·6	5 11·8		21 2·9	22 9·2
	17 20·8	19 3·1		6 18·1	8 0·3		23 15·4	24 21·7
	20 9·3	21 15·5		9 6·6	10 12·8		26 3·9	27 10·2
	22 21·8	24 4·0		11 19·1	13 1·3		28 16·4	29 22·7
	25 10·3	26 16·5		14 7·5	15 13·8	May	1 4·9	2 11·2
	27 22·8	29 5·0		16 20·0	18 2·3		3 17·4	4 23·7
	30 11·2	31 17·5		19 8·5	20 14·8		6 5·9	7 12·2
Feb.	1 23·7	3 6·0		21 21·0	23 3·3		8 18·4	10 0·6
	4 12·2	5 18·5		24 9·5	25 15·8		11 6·9	12 13·1
	7 0·7	8 6·9		26 22·0	28 4·2		13 19·4	15 1·6
	9 13·2	10 19·4		29 10·5	30 16·7		16 7·9	17 14·1

1885.	N.	h	S.	h		N.	h	S.	h		N.	h	S.	h
Feb.	12	1·7	13	7·9	Mar.	31	23·0	A. 2	5·2	May	18	20·4	20	2·6
	14	14·2	15	20·4	Apr.	3	11·5	4	17·7		21	8·9	22	15·1
	17	2·7	18	8·9		6	0·0	7	6·2		23	21·4	25	3·6
	19	15·1	20	21·4		8	12·5	9	18·7		26	9·9	27	16·1
	22	3·6	23	9·9		11	1·0	12	7·2		28	22·4	30	4·6
	24	16·1	25	22·4		13	13·5	14	19·7		31	10·9	J. 1	17·1
	27	4·6	28	10·8		16	2·0	17	8·2	June	2	23·4	4	5·6

Umbriel.

1885.	N.	h	S.	h		N.	h	S.	h		N.	h	S.	h
Jan.	12	11·8	14	13·6	Mar.	3	5·3	5	7·1	Apr.	21	23·0	24	0·7
	16	15·3	18	17·0		7	8·8	9	10·5		26	2·4	28	4·2
	20	18·7	22	20·5		11	12·3	13	14·0		30	5·9	M. 2	7·6
	24	22·2	26	23·9		15	15·7	17	17·5	May	4	9·4	6	11·0
	29	1·7	31	3·4		19	19·2	21	20·9		8	12·8	10	14·6
Feb.	2	5·1	4	6·8		23	22·7	26	0·4		12	16·3	14	18·0
	6	8·6	8	10·2		28	2·1	30	3·9		16	19·8	18	21·5
	10	12·0	12	13·8	Apr.	1	5·6	3	7·3		20	23·2	23	1·0
	14	15·5	16	17·2		5	9·1	7	10·8		25	2·7	27	4·5
	18	19·0	20	20·7		9	12·5	11	14·3		29	6·2	31	7·9
	22	22·4	25	0·1		13	16·0	15	17·7	June	2	9·7	4	11·4
	27	1·9	M. 1	3·6		17	19·5	19	21·2		6	13·1	8	14·9

Titania.

Super. Conj.		h	N. Elong.		h	Infer. Conj.		h	S. Elong.		h
			Jan	10	3·8	Jan.	12	8·1	Jan.	14	12·3
Jan.	16	16·6		18	20·8		21	1·0		23	5·3
	25	9·5		27	13·7		29	18·0		31	22·2
Feb.	3	2·5	Feb.	5	6·7	Feb.	7	10·9	Feb.	9	15·2
	11	19·4		13	23·6		16	3·9		18	8·1
	20	12·4		22	16·6		24	20·8		27	1·1
Mar.	1	5·3	Mar.	3	9·6	Mar.	5	13·8	Mar.	7	18·0
	9	22·3		12	2·5		14	6·8		16	11·0
	18	15·3		20	19·4		22	23·7		25	4·0
	27	8·2		29	12·5		31	16·7	Apr.	2	21·0
Apr.	5	1·2	Apr.	7	5·4	Apr.	9	9·7		11	13·9
	13	18·2		15	22·4		18	2·7		20	6·9
	22	11·2		24	15·4		26	19·6		28	23·9
May	1	4·1	May	3	8·4	May	5	12·6	May	7	16·9
	9	21·1		12	1·3		14	5·6		16	9·8
	18	14·1		20	18·3		22	22·6		25	2·8
	27	7·0		29	11·3		31	15·5	June	2	19·8

Oberon.

Super. Conj.		h	N. Elong.		h	Infer. Conj.		h	S. Elong.		h
Jan.	11	16·3	Jan.	15	1·1	Jan.	18	9·9	Jan.	21	18·6
	25	3·4		28	12·2		31	21·0	Feb.	4	5·8
Feb.	7	14·6	Feb.	10	23·4	Feb.	14	8·1		17	16·9
	21	1·7		24	10·5		27	19·3	Mar.	3	4·1
Mar.	6	12·9	Mar.	9	21·7	Mar.	13	6·5		16	15·3
	20	0·1		23	8·9		26	17·7		30	2·5
Apr.	2	11·3	Apr.	5	20·1	Apr.	9	4·9	Apr.	12	13·7
	15	22·5		19	7·3		22	16·1		26	0·9
	29	9·7	May	2	18·5	May	6	3·3	May	9	12·0
May	12	20·8		16	5·6		19	14·4		22	23·2
	26	8·0		29	16·8	June	2	1·6	June	5	9·8

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. JANUARY 9, 1885. No. 3

Edwin Dunkin, F.R.S., President, in the Chair.

Lieut. W. St. L. Chase, Quetta, Beloochistan;

Latimer Clark, M.I.C.E., F.R.G.S., 6 Westminster Chambers, Victoria Street, S.W.;

Walter Goodacre, 6 Gurney Villas, Clova Road, Forest Gate, E.;

George Hamilton, Warborough, Seabank Road, Liscard, Cheshire;

Rev. Andrew Henderson, Castlehead, Paisley;

William John Ibbetson, B.A., 26 Bateman Street, Cambridge;

Rev. Geo. W. James, F.R.H.S., Tuscarora, Nevada, U.S.A.;

Asutosh Mukhopadyay, 68 Russa Paglah Road, Bhowanipore, Calcutta;

Prof. Kavasjee D. Nacgamvala, M.A., F.C.S., Elphinstone College, Bombay;

Thomas Cunningham Porter, B.A., The Grammar School, Carlisle;

Captain B. Thomson, R.N.R., Ghyllbank, St. Helen's, Lancashire;

H. H. Turner, Esq., B.A., Royal Observatory, Greenwich, S.E., and Shurland House, Humber Road, Westcombe Park, S.E.; and

James Wigglesworth, New Parks House, Falsgrave, Scarborough;

were balloted for and duly elected Fellows of the Society.

On the Proposed Change of the Astronomical Day. By Professor Simon Newcomb.

The recommendation of the recent Meridian Conference at Washington, that the astronomical and nautical days be arranged as soon as practicable to begin at mean midnight, has received so much attention at the hands of English and American astronomers, as to indicate its possible adoption in some quarters without due consideration of the radical character of the proposed change. I therefore desire to set forth my reasons for counselling caution in this proceeding.

Outside of statements of purely astronomical data the proposed universal day may well prove a great convenience. In the reckoning of physical and meteorological phenomena there has hitherto been no recognised standard of time in general use. For such purposes I see nothing better than the general adoption of the day beginning at Greenwich mean midnight as proposed by the Conference. Moreover, could the human race commence its work anew by obliterating the past, there would be a certain advantage in having the astronomical reckoning of time to correspond with the universal time in other departments of science; and this advantage would probably more than compensate for the loss of that simplicity and generality which inheres in the system of counting the hours from the moment when the hour-angle of the mean sun is zero. It is not plain, however, that the lack of accordance between the two reckonings of time will lead to any serious trouble or confusion. Astronomical ephemerides and observations form, so to speak, a department by themselves, which none have occasion to enter except those who are thoroughly conversant with the two methods of reckoning time. I can recall no instance of trouble or confusion in the past arising from the difference between the astronomical and the civil day.

So far as astronomical observations and ephemerides are concerned, the change, if made at all, must be made throughout, as it would be intolerable to have two methods of reckoning time in the same connected set of publications. It is, then, subject to the objection that it would cause great trouble and confusion, not only to ourselves, but to future astronomers, through as many generations as made use of our observations and ephemerides. A glance at the *Nautical Almanac* will, I conceive, convince us of this. If we are to have but one system, then, on page 11 of the month the data must be given for Greenwich midnight instead of noon, and the sidereal time must be that for midnight. If we do not do this there will be additions and subtractions of 12 hours to be performed by all future generations in changing sidereal to mean time. On page 4 the columns for midnight and noon must be interchanged. On pages 5 to 12 the hours must be reckoned from midnight. The consequence will be that

whenever the astronomer of 20 or 100 years hence has occasion to refer to the ephemeris, he must know and bear in mind which reckoning of time is adopted, else his place of the Moon will be taken out 12 hours in error. The same remark will apply to all data for which hours of time are given. To continually remember anything of this sort is a mental burden which no one can always be sure of carrying. If we could be sure of this, accidents and inadvertences would be almost unknown in the world. The ephemeris of the planets would, for consistency, have to be given for midnight instead of noon. Thus, there would be a break of half a day in the series which now progresses regularly at 24-hour intervals.

It might, indeed, be said that this ephemeris could just as well be continued for noon as given for midnight. But this would be simply a half-way step, and would lead to the difficulty that in interpolating to any required number of hours universal time, the 12 hours would have to be subtracted whenever a place of the planet had to be interpolated. I pass over a number of other points connected with the change; among them the fact that the instructions and precepts respecting time given in our books on practical astronomy will have to be changed. It is a general rule that the judgment of men, on the whole, errs as much on one side of any question as on the other. But my experience leads me to think that a decided exception to this rule arises when the question is that of changing a well-established and consistent set of methods and habits in organised work, and that we always under-estimate the trouble and confusion such changes will cause us. It is very clear to me that the change is one which ought not to be made at all, unless some stronger reason for it than is now presented shall be pointed out. In this case it ought to be made at some common fundamental epoch by an arrangement among the astronomers of the world. The beginning of the coming century would be a very good epoch, and would allow about the right time for consideration. If a ten years' continuance of the present system shows that it needs amendment, the change can then be made with less trouble than at any other time.

Faint Stars for Standards of Stellar Magnitude.

(*Extract from a Letter from Prof. Pickering.*)

The charts accompanying this circular represent four out of twenty-four regions from which it is proposed to select certain stars for standards of the magnitude of faint stars. Additional information with regard to the plan is given in the printed Reports sent herewith. The regions represented in these four charts are those from 2^m to 6^m following the bright stars γ *Pegasi*, ϵ *Orionis*, η *Virginis*, and η *Serpentis*. Each region extends 5′ north and 5′ south of the Declination of the corresponding bright star.

It is desirable that these charts should be made as complete as possible, and it is hoped that astronomers having the use of powerful telescopes will assist in accomplishing this object. They will confer a favour upon the Observatory of Harvard College by comparing these charts with the regions which they represent, and marking upon them the places of any additional stars which may be visible. Some indications of the comparative brightness of these stars would also be desirable.

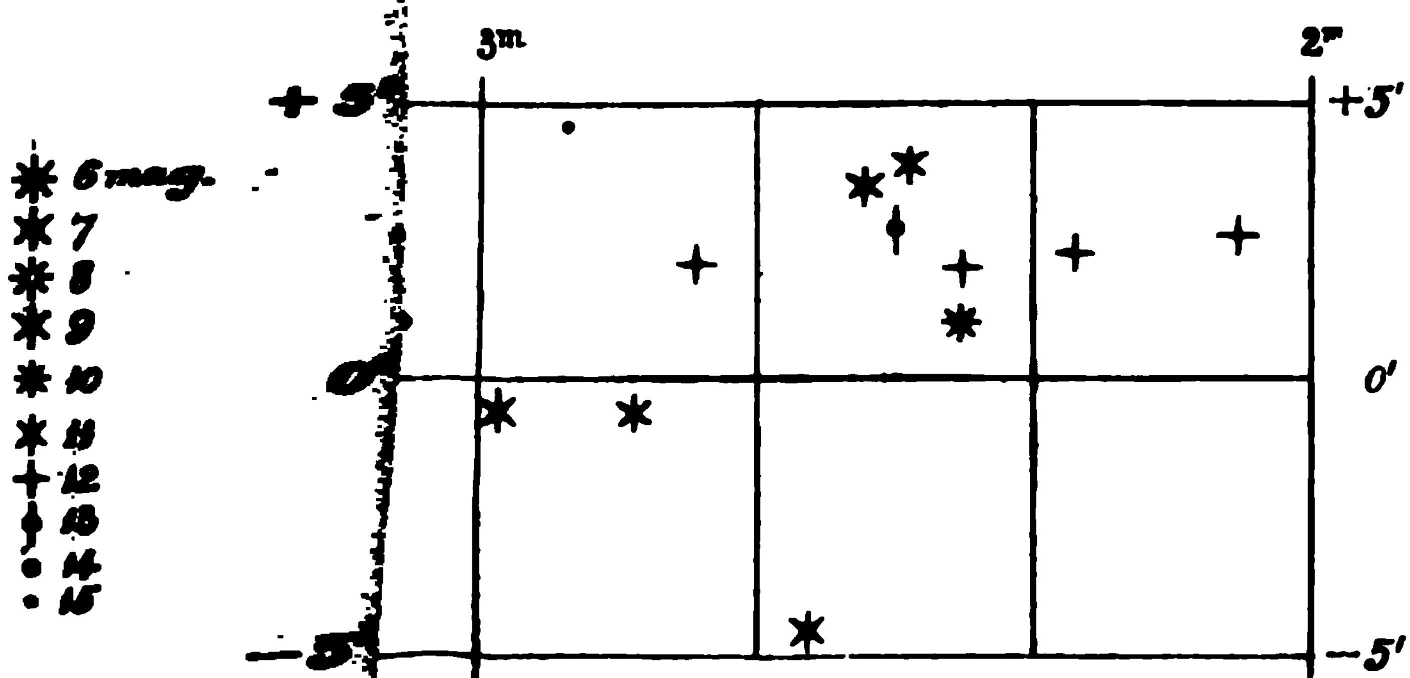
Astronomers who may be disposed to take part in this work are requested to send the chart of any particular region, as soon as possible after its revision, to the address given below.

Harvard College Observatory,
Cambridge, Mass. (*U.S.*):
1884, *Dec.* 17.

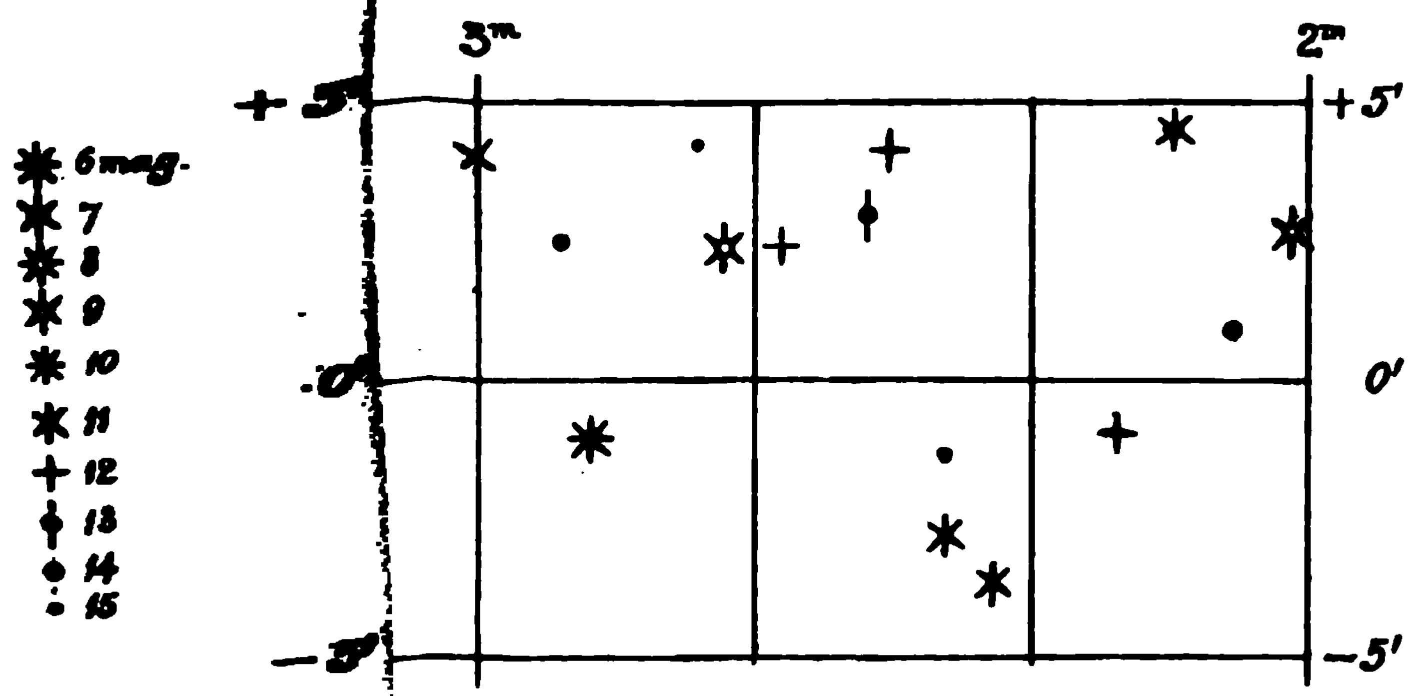
Second Report of the Committee on Standards of Stellar Magnitudes.

The first Report of this Committee (*Proc. Amer. Assoc.* XXX. p. 1) included a plan for the determination of standards for stars fainter than the tenth magnitude. Twenty-four bright equatorial stars were chosen, and the standards were to be selected from the regions following them from two to six minutes of time, and not differing in Declination from the leading stars by more than five minutes of arc. The observations described below have been made at the Harvard College Observatory unless otherwise stated. The light of each of the leading stars has been determined on from seven to eighteen nights with the meridian photometer. Charts have been constructed of all the stars visible with the 15-in. telescope, in all but three of the regions from which the standards are to be selected. Most of these charts have been submitted to a careful scrutiny with the 15-in. telescope of the Washburn Observatory. An important test of the completeness of the charts is thus afforded.

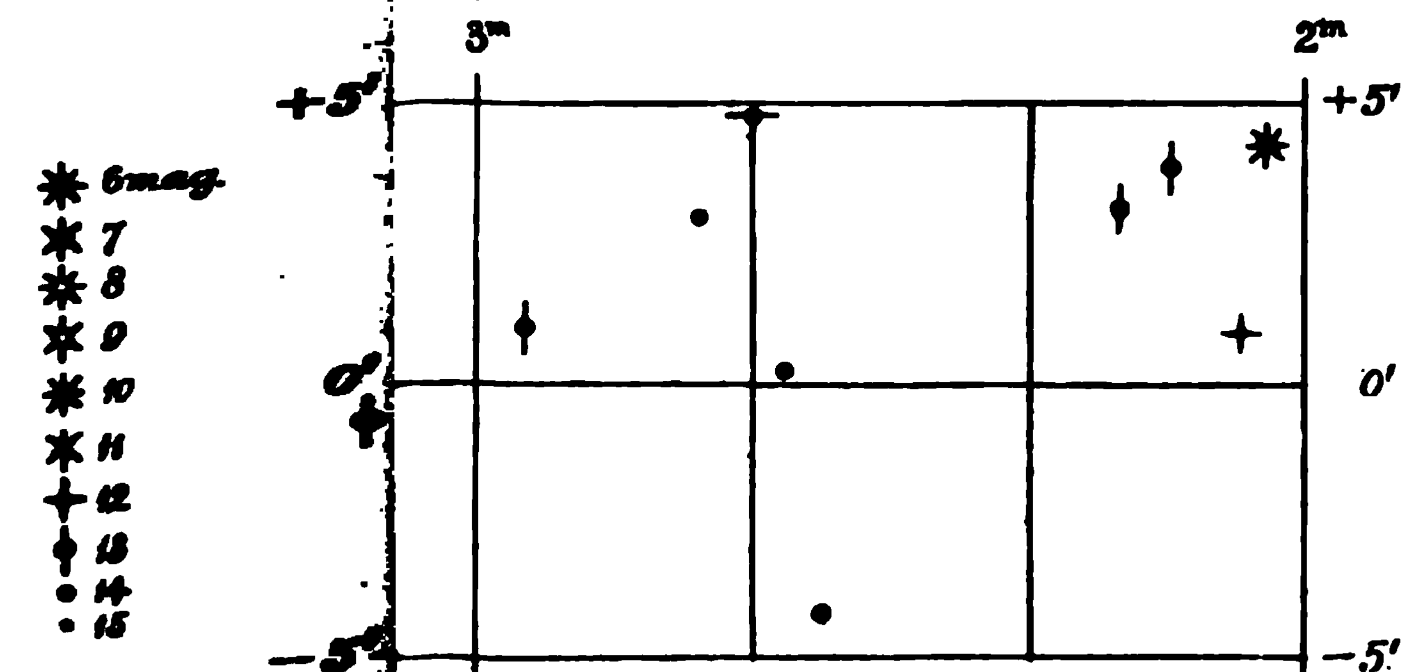
In the following table three successive columns give the names of the twenty-four leading stars and their approximate Right Ascensions and Declinations for 1880. The next two



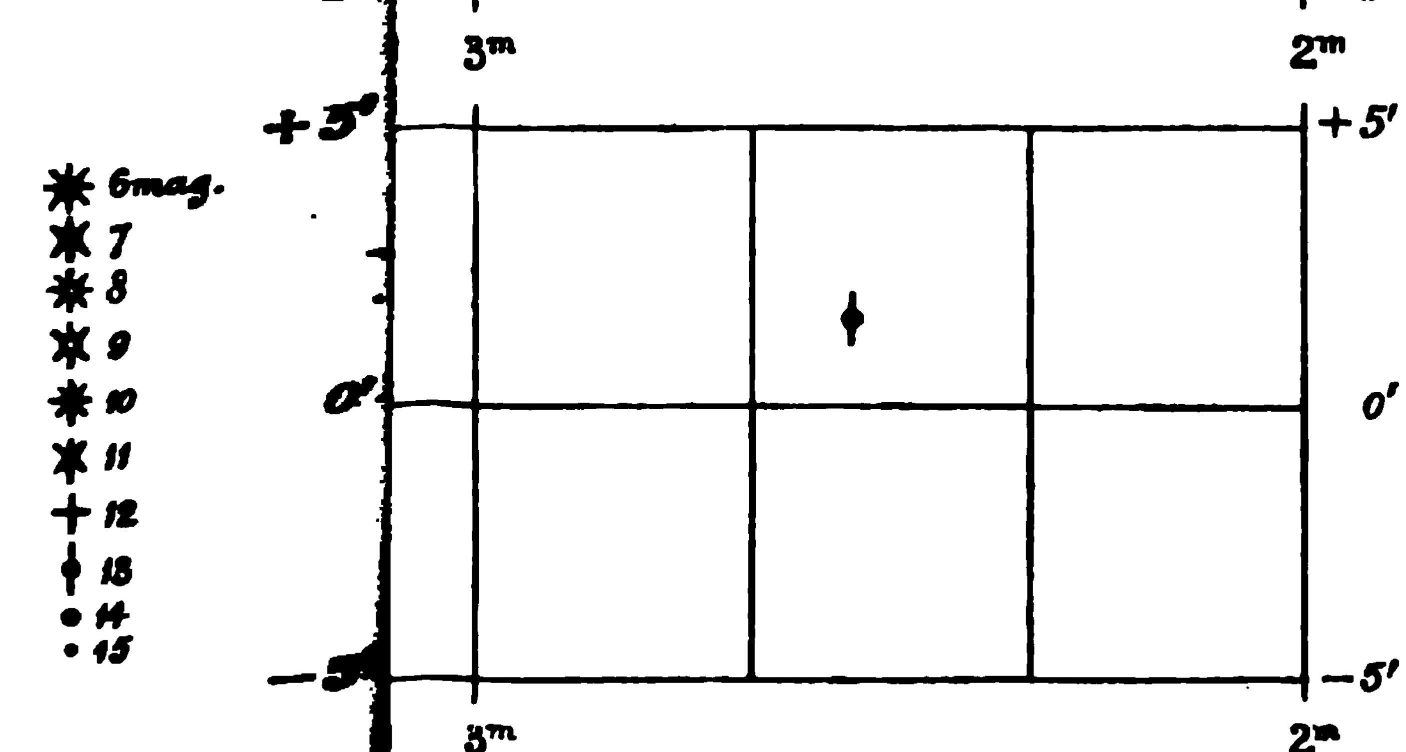
Region following γ Pegasi



Region following ε Orionis.



Region following η Virginis.



Region following η Serpentis.

columns give the number of nights on which they were observed with the meridian photometer, and the resulting magnitude. The details of these measures and a comparison with various other determinations of their light will be found in the *Harv. Observ. Annals*, vol. xiv. The last columns give the number of stars in each of the charts, and the corresponding number of stars contained in the same portions of the *Durchmusterung*.

Stars suitable for standards must next be selected by the help of the charts. The light of these stars should then be measured in as many different ways as possible. The Committee will be much indebted for aid that may be rendered them in this portion of their work. The early publication of the charts now becomes a matter of importance, as it would permit their immediate use for various purposes.

Name.	R.A. 1880.	Dec. 1880.	No. Nights.	Phot. Mag.	Stars on Chart.	D. M. Stars.
	h m	° ′				
γ Pegasi	0 7·1	+14 31	13	3·04	49	3
θ¹ Ceti	1 18·0	− 8 48	12	3·77	27	
α Piscium	1 55·9	+ 2 11	12	3·99		1
α Ceti	2 56·0	+ 3 37	11	2·68		2
γ Eridani	3 52·4	−13 51	10	3·05	30	
α Tauri	4 29·0	+16 16	16	1·00	19	3
ε Orionis	5 30·1	− 1 17	16	1·76	42	6
γ Geminorum	6 30·8	+16 30	17	2·00	150	5
α Canis Min.	7 33·0	+ 5 32	15	0·46	96	3
ε Hydræ	8 40·4	+ 6 51	7	3·58	64	4
α Leonis	10 2·0	+12 33	15	1·42	39	1
θ Leonis	11 7·0	+16 5	10	3·47	24	3
η Virginis	12 13·8	+ 0 0	10	4·05	23	2
α Virginis	13 18·9	−10 32	13	1·23	30	
α Boötis	14 10·2	+19 48	13	0·03	25	1
β Libræ	15 10·5	− 8 56	14	2·74	39	
δ Ophiuchi	16 8·1	− 3 23	11	2·77	48	
η Ophiuchi	17 3·5	−15 34	10	2·62	100	
η Serpentis	18 15·1	− 2 56	10	3·35	7	
δ Aquilæ	19 19·4	+ 2 53	14	3·46		3
θ Aquilæ	20 5·1	− 1 11	10	3·39	110	2
β Aquarii	21 25·2	− 6 6	10	3·14	52	
α Aquarii	21 59·6	− 0 54	10	3·16	48	0
α Pegasi	22 58·8	+14 34	18	2·61	29	3

Note on the Track of the Total Phase in the Solar Eclipse of 1885, Sept. 8, in its passage across New Zealand. By J. R. Hind, LL.D., F.R.S.

The only land traversed by the central line in the total eclipse of the Sun in September next will be the southern part of the north island and the northern part of the south island of New Zealand, where the eclipse occurs early on the morning of the 9th, civil reckoning. The following are points in the central line corresponding to the annexed Greenwich mean times, with the duration of totality on that line. The positions of Sun and Moon, and the semi-diameters, have been taken from the *Nautical Almanac*:—

Greenwich M.T.	Long. E.	Lat. S.	Duration of totality.
h m	° ′	° ′	m s
Sept. 8 8 2	171 28·5	40 28·5	1 50·3
8 3	172 47·2	40 33·3	1 52·5
8 4	173 59·1	40 38·8	1 54·6
8 5	175 5·7	40 44·8	1 56·5
8 6	176 8·2	40 51·3	1 58·4

On referring these points to the Admiralty general chart of New Zealand, it will appear that the central eclipse enters the south island between Wanganui Inlet and Cape Farewell, and leaves the north island a little north of Castle Point, near which will be the most favourable position for observation. Taking the position of Cape Farewell in longitude 172° 43 E., latitude 40° 30′·5 S., the total eclipse begins Sept. 8, at $19^h\ 32^m\ 49^s$ local mean time, and continues $1^m\ 52^s$, with the Sun at an altitude of about 15°. For any point near Cape Farewell the Greenwich mean time (t) of beginning and ending of the total phase will be given by the formulæ

$$\cos\omega = -113{\cdot}1590-[2{\cdot}09859]\sin l+[1{\cdot}62923]\cos l.\cos(\lambda-162°\ 3'{\cdot}3)$$
$$t = 8^h\ 58^m\ 31^s{\cdot}1 \mp [1{\cdot}74986]\sin.\omega-[3{\cdot}36498].\sin l$$
$$-[3{\cdot}85019].\cos l.\cos(\lambda-146°\ 20'{\cdot}4)$$

Here l is the *geocentric* latitude, and λ the east longitude, from Greenwich, taken positive. The upper sign is to be used for the beginning, and the lower sign for the ending. The quantities within the square brackets are logarithms.

The position of Castle Point, read off from the chart, is in longitude 176° 14′ E., latitude 40° 54′ S., and a direct calculation gives the commencement of totality at $19^h\ 50^m\ 8^s$ local mean time, and duration of totality $1^m\ 58^s{\cdot}6$, the Sun's altitude

about 18°. For any neighbouring position the beginning and ending of the total phase may be determined from the expressions

$$\cos \omega = -110{\cdot}2757 - [2{\cdot}08444] \sin l + [1{\cdot}62804] \cos l \,.\, \cos (\lambda - 160^\circ\ 52'{\cdot}8)$$

$$t = 8^h\ 58^m\ 13^s{\cdot}6 \mp [1{\cdot}77303] \sin .\, \omega - [3{\cdot}38763] \sin l$$
$$- [3{\cdot}85920] \cos l \,.\, \cos (\lambda - 145^\circ\ 34'{\cdot}2)$$

At Wellington totality begins at $19^h\ 44^m\ 9^s$ local mean time, and continues $1^m\ 31^s$. At Nelson it begins at $19^h\ 37^m\ 22^s$, and continues $1^m\ 11^s$.

The Greenwich time of commencement of the eclipse, near Castle Point, may be found from the expressions

$$\cos \omega = -1{\cdot}55171 - [0{\cdot}24636] \sin l + [9{\cdot}74289] \,.\, \cos l \,.\, \cos (\lambda - 178^\circ\ 48'{\cdot}8)$$

$$t = 9^h\ 2^m\ 51^s{\cdot}9 - [3{\cdot}57430] \sin \omega - [3{\cdot}29927] \sin l$$
$$- [3{\cdot}82250] \cos .\, l \,.\, \cos (\lambda - 161^\circ\ 21'{\cdot}5)$$

The contact takes place at about 62° N. to W. (direct). For Castle Point the equations give the partial beginning at $18^h\ 45^m\ 47^s$ local mean time. The Sun will be at an altitude of 6½°.

With regard to the latitude limits of total phase, they may be stated approximately at +49′ for N. limit and −50′ for S. limit, but a closer computation appears unnecessary. For satisfactory observation during the totality of the approaching eclipse, the observer must place himself as nearly as practicable upon the central line. It will be found that the above determination of its course, from my own computations, agrees closely with that indicated in the *American Ephemeris.*

The Observations of the Moon made at the Radcliffe Observatory, during the year 1884, *and a Comparison of the Results with the Tabular Places from Hansen's Lunar Tables.* By E. J. Stone, M.A., F.R.S.

The present paper contains the Right Ascensions and North Polar Distances of the Moon as deduced from the observations made at the Radcliffe Observatory during the year 1884. I have compared these results with those deduced from Hansen's Lunar Tables on two suppositions:—

1. That the mean times, found in the usual way from the sidereal times at mean noon given in the *Nautical Almanac*, were not changed in 1864.
2. That the mean times were changed in 1864, in accordance

with the views which I have explained in papers already communicated to the Society.

The following facts should be borne in mind:—

(1) Hansen's Lunar Tables represented the motions of the Moon with great accuracy for many years before 1863. The mean yearly error, 1847–1864, was always small, generally about $-1''\cdot 5$.

(2) In 1864 we changed the scale upon which our mean times are measured, or the ratio of the sidereal day to the tabular day. This is now admitted.

(3) I have given mathematical proofs, which no one in my opinion has shown to be in error, that this change of unit requires the correction

$$24^{\mathrm{h}}.\frac{\delta n}{n}.t$$

to be applied to our present sidereal times at mean noon, in order to obtain the sidereal time at Bessel's old mean noon, to which our tabular quantities refer. This correction is equivalent to a change of the adopted unit in the proportion of

$$1 : \left(1+\frac{\delta n}{n}\right).$$

(4) When this correction is applied to our mean times, the discordances between Hansen's Lunar Tables and observations for the twenty-one years 1864–1884 are sensibly the same as they were before 1863.

The mean of the four greatest negative errors in the comparison of Hansen's Tables in Longitude with the Greenwich observations was $-9''\cdot 08$ in 1862, and $-6''\cdot 95$ in 1863; whilst the mean of the four greatest positive errors was respectively $+1''.51$ in 1862, and $+3''\cdot 52$ in 1863. The Radcliffe observations in 1882, 1883, and 1884, show corresponding mean errors of $-7''\cdot 17$, $-6''\cdot 60$, and $-8''\cdot 01$, and $+3''\cdot 93$, $+3''\cdot 50$, and $+4''\cdot 69$ respectively.

Table I.

Radcliffe Observations of the Moon, 1884.

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.		Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff (H.−Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s				h m s	s	s	s	s	° ′ ″	″	″	″	″
29·83	R.	Jan.	10	5 48 51·52	52·28	+0·76	−1·27	−0·51	70 51 51·14	50·29	−0·85	−0·47	−1·32
29·83	R.		11	6 52 7·49	8·26	+0·77	−1·24	−0·47	71 55 30·37	31·84	+1·47	−2·03	−0·56
29·84	F.B.		12	7 53 10·64	11·78	+1·14	−1·19	−0·05					
29·92	F.B.	Feb.	2	1 24 55·80	56·62	+0·82	−1·13	−0·31	80 47 61·08	59·57	−1·51	+5·05	+3·54
29·94	R.		6	5 24 36·72	37·29	+0·57	−1·24	−0·67	70 59 35·88	34·55	−1·33	+0·22	−1·11
29·94	F.B.		7	6 26 22·56	23·47	+0·91	−1·23	−0·32	71 27 27·93	31·64	+3·71	−1·31	+2·40
30·05	R.	Mar.	5	6 7 14·46	15·14	+0·68	−1·22	−0·54	71 22 4·39	6·74	+2·35	−0·80	+1·55
30·05	F.B.		6	7 7 1·98	2·81	+0·83	−1·18	−0·35	72 36 59·51	61·37	+1·86	−2·17	−0·31
30·06	R.		7	8 4 48·20	48·89	+0·69	−1·14	−0·45	74 54 29·72	32·55	+2·83	−3·32	−0·49
30·06	F.B.		8	9 0 13·69	14·51	+0·82	−1·09	−0·27	78 1 50·18	53·99	+3·81	−4·18	−0·37
30·07	R.		10	10 44 35·18	35·90	+0·72	−1·02	−0·30	85 48 27·37	32·25	+4·88	−5·06	−0·18
30·08	R.		12	12 23 12·38	13·26	+0·88	−0·98	−0·10	94 6 36·56	39·22	+2·66	−4·88	−2·22
30·09	R.		14	14 0 19·89	20·85	+0·96	−0·99	−0·03	101 25 2·98	4·80	+1·82	−3·89	−2·07
30·10	R.		18	17 21 53·54	54·66	+1·12	−1·06	+0·06	108 42 34·30	34·40	+0·10	−0·26	−0·16

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.	Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s			h m s	s	s	s	s	° ′ ″	″	″	″	″
30·17	F.B.	Apr. 5	9 36 39·43	40·40	+0·97	−1·06	−0·09	80 34 55·02	58·46	+3·44	−4·54	−1·10
30·19	F.B.	9	12 53 55·01	55·92	+0·91	−0·98	−0·07	96 35 19·78	23·74	+3·96	−4·62	−0·66
30·19	W.	10						100 10 36·37	43·28	+6·91	−4·12	+2·79
30·20	F.B.	12	15 20 47·09	48·43	+1·34	−1·02	+0·32	105 47 7·69	9·81	+2·12	−2·63	−0·51
30·29	F.B.	May 3	10 12 17·67	18·54	+0·87	−1·03	−0·16	83 14 6·57	11·23	+4·66	−4·85	−0·19
30·29	R.	5	11 50 34·99	35·83	+0·84	−0·98	−0·14	91 22 39·19	43·30	+4·11	−4·97	−0·86
30·30	F.B.	6	12 38 25·59	26·54	+0·95	−0·97	−0·02	95 20 45·73	48·69	+2·96	−4·72	−1·76
30·30	R.	7	13 26 17·65	18·35	+0·70	−0·98	−0·28	99 2 22·55	25·21	+2·66	−4·30	−1·64
30·31	F.B.	8	14 14 40·11	41·21	+1·10	−0·99	+0·11	102 18 54·70	57·44	+2·74	−3·70	−0·96
30·31	R.	9	15 3 53·84	54·70	+0·86	−1·01	−0·15	105 2 13·61	15·92	+2·31	−2·94	−0·63
30·31	F.B.	10	15 54 5·04	6·25	+1·21	−1·03	+0·18	107 4 53·91	53·94	+0·03	−2·05	−2·02
30·44	W.	June 10	19 4 34·59	36·06	+1·47	−1·07	+0·40	107 32 45·94	44·63	−1·31	+1·85	+0·54
30·44	F.B.	11	19 56 35·90	37·26	+1·36	−1·06	+0·30	105 37 12·17	10·70	−1·47	+2·87	+1·40
30·53	F.B.	July 2	14 31 19·34	20·42	+1·08	−1·00	+0·08	103 4 17·41	21·34	+3·93	−3·55	+0·38
30·53	W.	3	15 20 39·68	40·72	+1·04	−1·02	+0·02	105 38 5·14	7·77	+2·63	−2·75	−0·12
30·55	R.	7	18 47 15·94	17·01	+1·07	−1·08	−0·01	108 1 61·42	59·33	−2·09	+1·45	−0·64
30·55	W.	8	19 39 53·07	54·24	+1·17	−1·08	+0·09	106 24 61·10	59·30	−1·80	+2·52	+0·72
30·55	F.B.	9	20 32 9·69	10·95	+1·26	−1·07	+0·19	103 57 55·39	51·30	−4·09	+3·49	−0·60

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.	Observed R.A.	Secs. of Hansen's R.A.	Diff. (H.—Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.—Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s			h m s	s	s	s	s	° ′ ″	″	″	″	″
30·56	R.	July 11	22 15 26·40	27·57	+1·17	−1·06	+0·11	97 1 15·91	11·86	−4·05	+4·93	+0·88
30·64	W.	31	15 52 16·01	17·01	+1·00	−1·04	−0·04	106 41 6·67	5·36	−1·31	−2·23	−3·54
30·65	R.	Aug. 1	16 43 12·19	13·12	+0·93	−1·06	−0·13	108 5 8·29	7·22	−1·07	−1·23	−2·30
30·65	F.B.	2	17 35 1·63	2·67	+1·04	−1·08	−0·04	108 38 46·00	45·29	−0·71	−0·15	−0·86
30·66	F.B.	4	19 20 23·29	24·31	+1·02	−1·09	−0·07	107 4 15·64	11·88	−3·76	+2·09	−1·67
30·66	W.	5	20 13 15·44	16·50	+1·06	−1·09	−0·03	104 56 54·56	49·80	−4·76	+3·14	−1·62
30·67	F.B.	6	21 5 54·25	55·66	+1·41	−1·08	+0·33	102 1 38·81	34·36	−4·45	+4·05	−0·40
30·67	W.	7	21 58 17·91	19·29	+1·38	−1·08	+0·30	98 26 17·66	13·78	−3·88	+4·78	+0·90
30·76	R.	29	17 14 3·32	4·01	+0·69	−1·07	−0·38	108 20 17·01	16·17	−0·84	−0·61	−1·45
30·77	R.	Sept. 1	19 51 5·45	6·32	+0·87	−1·09	−0·22	105 50 15·58	12·11	−3·47	+2·67	−0·80
30·77	F.B.	2	20 43 53·34	54·36	+1·02	−1·09	−0·07	103 16 26·75	22·16	−4·59	+3·67	−0·92
30·78	W.	4	22 29 47·47	48·43	+0·96	−1·10	−0·14	96 2 35·15	30·54	−4·61	+5·15	+0·54
30·79	R.	5	23 23 15·74	16·74	+1·00	−1·11	−0·11	91 42 38·70	33·78	−4·92	+5·54	+0·62
30·87	W.	27	18 36 9·97	10·95	+0·98	−1·08	−0·10	107 55 15·80	14·33	−1·47	+1·10	−0·37
30·88	R.	29	20 20 6·31	7·11	+0·80	−1·08	−0·28	104 26 58·33	55·21	−3·12	+3·19	+0·07
30·89	W.	30	21 12 19·28	20·25	+0·97	−1·09	−0·12	101 30 53·29	48·02	−5·27	+4·10	−1·17
30·90	R.	Oct. 3	23 52 35·95	36·86	+0·91	−1·14	−0·23	89 15 46·66	43·28	−3·38	+5·68	+2·30
30·90	F.B.	4	0 48 34·51	35·59	+1·08	−1·18	−0·10	84 42 13·26	10·50	−2·76	+5·58	+2·82

Corr. to be subtracted from M.T. computed directly from Sid. Time at Mean Noon from N.A.	Obs.	Day. 1884.	Observed R.A.	Secs of Hansen's R.A.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in R.A.	Observed N.P.D.	Secs. of Hansen's N.P.D.	Diff. (H.−Obs.)	Corr. due to Error in Time.	Residual Error in N.P.D.
s			h m s	s	s	s	s	° ′ ″	″	″	″	″
30.93	R.	Oct 12	8 53 35.72	37.73	+1.01	−1.16	−0.15	77 21 14.97	18.24	+3.27	−4.06	−0.79
31.00	W.	28	21 40 27.03	27.97	+0.94	−1.07	−0.13	99 41 19.39	15.07	−4.32	+4.45	+0.13
31.00	R.	29	22 32 11.70	12.65	+0.95	−1.09	−0.14	95 51 12.78	9.17	−3.61	+5.10	+1.49
31.02	R.	Nov. 3	3 18 49.66	50.75	+1.09	−1.32	−0.23	74 58 43.71	40.57	−3.14	+3.64	+0.50
31.03	R.	6	6 33 52.30	53.41	+1.11	−1.32	−0.21	71 58 10.62	11.40	+0.78	−1.28	−0.50
31.04	F.B.	7	7 36 24.70	26.18	+1.48	−1.27	+0.21	73 36 12.09	13.56	+1.47	−2.73	−1.26
31.05	R.	9	9 32 7.61	8.67	+1.06	−1.14	−0.08	79 41 10.64	17.48	+6.84	−4.61	+2.23
31.11	R.	24	21 20 22.87	23.55	+0.68	−1.05	−0.37	101 12 43.33	39.68	−3.65	+4.06	+0.41
31.12	R.	28	0 47 13.18	14.02	+0.84	−1.15	−0.31	84 56 58.68	54.24	−4.44	+5.55	+1.11
31.13	F.B.	29	1 44 7.08	8.12	+1.04	−1.22	−0.18	80 37 60.26	57.13	−3.13	+5.18	+2.05
31.23	W.	Dec. 26	1 18 24.29	25.37	+1.08	−1.15	−0.07	82 45 44.47	41.96	−2.51	+5.25	+2.74
31.25	W.	30	5 24 15.12	15.97	+0.85	−1.39	−0.54	71 34 28.72	27.91	−0.81	+0.69	−0.12
31.25	F.B.	31	6 31 26.47	27.48	+1.01	−1.39	−0.38	71 45 3.37	4.81	+1.44	−1.15	+0.29
Mean of Errors without regard to sign				...	0.989		0.207			2.907		1.140
Mean Errors for Year ...		...	...	...	+0.989		−0.120			−0.270		−0.094

Observers.—W., Mr. Wickham; R., Mr. Robinson; F.B., Mr. Bellamy.

TABLE II.

Radcliffe Observations of the Moon, 1884.

Errors of Longitude and Ecliptic Polar Distance. Corrected and Uncorrected for Error in Mean Time.

Day, 1884.	Errors of Longitude. Corrected for Error in Time.	Uncorrected.	Errors of E.N.P.D. Corrected for Error in Time.	Uncorrected.
	"	"	"	"
Jan. 10	−7·22	+10·82	−1·47	−0·62
11	−6·75	+11·11	+0·04	+0·48
Feb. 2	−5·58	+11·84	+1·58	+3·12
6	−9·44	+ 8·17	−1·70	−0·82
7	−4·46	+13·14	+2·60	+3·12
Mar. 5	−7·69	+ 9·74	+1·66	+2·21
6	−5·03	+12·06	+0·28	+0·46
7	−6·50	+10·41	+0·85	+0·72
8	−3·92	+12·67	+0·77	+0·25
10	−4·23	+11·85	+1·52	+0·05
12	−2·25	+13·14	−1·44	−2·78
14	−1·13	+13·88	−1·79	−3·16
18	+0·84	+15·96	−0·22	−0·95
Apr. 5	−1·62	+14·75	−0·61	−1·38
9	−1·22	+14·05	−0·21	−1·59
12	+4·34	+19·27	−1·68	−2·91
May 3	−2·30	+13·81	+0·67	−0·26
5	−2·27	+13·22	+0·05	−1·24
6	−0·97	+14·20	−1·50	−2·85
7	−4·46	+10·62	+0·02	−1·38
8	+1·20	+16·13	−1·44	−2·77
9	−2·26	+12·62	0·00	−1·23
10	+2·11	+17·01	−2·52	−3·59
June 10	+5·65	+21·12	+1·17	+1·02
11	+4·00	+19·65	+2·21	+2·37
July 2	+1·23	+16·22	−0·01	−1·23
3	+0·25	+15·23	−0·19	−1·31
7	−0·09	+15·45	−0·65	−0·81
8	+1·16	+16·94	+0·93	+1·05
9	+2·84	+18·85	+0·10	+0·54
11	+1·22	+17·76	+1·41	+2·48

Day, 1884.	Errors of Longitude. Corrected for Error in Time.	Errors of Longitude. Uncorrected.	Errors of E.N.P.D. Corrected for Error in Time.	Errors of E.N.P.D. Uncorrected.
	"	"	"	"
July 31	−1·31	+13·79	−3·34	−4·32
Aug. 1	−2·15	+13·06	−2·04	−2·80
2	−0·61	+14·81	−0·83	−1·33
4	−0·77	+15·06	−1·79	−1·73
5	−0·07	+16·09	−1·68	−1·25
6	+4·76	+21·15	+1·02	+1·73
7	+3·88	+20·61	+2·37	+3·40
29	−5·52	+ 9·75	−1·02	−1·62
Sept. 1	−2·98	+13·03	−1·38	−1·06
2	−0·75	+15·63	−1·16	−0·53
4	−2·14	+15·04	−0·27	+1·00
5	−1·76	+15·75	−0·08	+1·37
27	−1·41	+14·11	−0·46	−0·60
29	−3·99	+12·07	−0·86	−0·38
30	−1·34	+15·23	−1·64	−0·80
Oct. 3	−4·08	+13·88	+0·74	+2·33
4	−2·48	+15·94	+2·01	+3·74
12	−2·34	+15·17	−0·16	−0·91
28	−1·86	+14·59	−0·50	+0·45
29	−2·50	+14·53	+0·61	+1·89
Nov. 3	−3·35	+16·09	−0·38	+1·06
6	−3·03	+15·92	−0·32	−0·15
7	+2·78	+21·32	−1·73	−2·01
9	−0·41	+17·05	+2·49	+1·50
24	−5·32	+10·66	−1·27	−0·42
28	−4·70	+13·29	−0·78	+0·80
29	−3·22	+15·50	+0·96	+2·59
Dec. 26	−2·00	+15·85	+2·15	+3·70
30	−7·68	+12·16	−0·60	−0·05
31	−5·41	+14·49	+0·59	+0·64
Mean of errors without regard to sign	3·096	14·645	1·091	1·556
Mean errors for year	−1·907	+14·645	−0·146	−0·111

Table III.

Observations of the Moon, 1862 to 1884.

Mean Errors of Longitude. Uncorrected and Corrected for Error in Mean Time.

Year.	Errors of Longitude. (Hansen − Observed). *Uncorrected.*	*Corrected.*
1862 Greenwich	− 2″·829	− 2″·829
1863	− 1·606	− 1·606*
1864	+ 0·121	− 0·814
1865	+ 1·271	− 0·220
1866	+ 2·142	− 0·217
1867	+ 3·480	+ 0·357
1868	+ 4·117	+ 0·280
1869	+ 4·277	− 0·352
1870	+ 4·828	− 0·657
1871	+ 6·955	+ 0·435
1872	+ 7·309	+ 0·097
1873	+ 8·239	+ 0·200
1874	+ 9·294	+ 0·561
1875	+ 9·867	+ 0·365
1876	+ 9·800	− 0·509
1877	+ 9·234	− 1·898
1878	+ 8·219	− 3·603
1879	+ 9·631	− 3·124
1880	+ 10·265	− 3·245
1881	+ 10·622	− 3·791
1882 Radcliffe	+ 12 927	− 2·508
1883 „	+ 14·615	− 1·547
1884 „	+ 14·645	− 1·907

On Screw-wear as affecting the N.P.D. of the Cape Catalogue for 1880. By E. J. Stone, M.A., F.R.S.

The statement which Mr. Gill has made of the existence of serious systematic errors in the North Polar Distances of the Cape Catalogue for 1880, due to the wear of the screws of the Transit Circle between 1856 and 1879, is one which is easily made; but which it will be found much more difficult to prove than to make.

* Here change in the unit of time took place.

That two surfaces which rub must to some extent wear is true; but that the relative wear over the five or six threads which are in continuous use in Observatory work is sufficient to lead to serious errors in the results is a question which can only be settled by a direct appeal to facts.

Fortunately, whilst at the Cape, I did directly examine this question. It was, and still is, my rule to test, from time to time, the working of the screws, as a whole, by observations of a fixed collimating mark, or, better still, by Nadir Point Determinations at different parts of the screws. If it can be shown that the screws will allow a direction to be accurately determined at any of the threads used in the work, then it is needless, for all practical purposes, to discuss further questions of screw-wear; and if any errors due to screw-wear or defects in the screws affect the results, such experiments as I have described will clearly indicate their magnitude.

The results of observations of the Nadir at 0^r and 2^r made in 1875 are printed in the Cape Observations for 1875; but in 1877, in consequence of discussions which had taken place in England with regard to screw-wear, observations of the Nadir direction were made over the whole range of the threads of the screws which *could* possibly be used in making observations, including some that no careful observer would think of using from the mere feel of the working of the screw. The result was to show that, so long as the observations were confined to the five or six middle threads of the screws which must be employed in passing from one division of the circle to the next, and which were constantly in use, the errors due to defect of the screws of the Cape instrument were restricted within very small limits indeed; but that the employment of one or two threads outside this necessary range soon brought relative errors into existence. The curve, which Mr. Gill has given, is the reproduction of one which I constructed from these observations in 1877. It shows clearly the smallness of the errors so long as the central threads are alone used; and the extreme rapidity with which the errors increase as the readings are unduly extended. But an inspection of the observations shows that no continuous curve can accurately represent the observations, the fact to which they point is a *per saltum* change at or about 5^r. Whether this rapid increase of error be due to constraint or not, the fact of the rapid increase of relative error when these outside threads are engaged is undoubted. Such rapidity of increase of the errors when the extreme threads of the screw are brought into play shows that it would be useless to compare errors of the screws at different times from a few existing readings, unless it were perfectly certain that no changes whatever had been made in the adjustment of the index from which the revolutions are taken. It would be quite possible that the screws should be working without error from 0^r to 5^r at one time, and that no inconsiderable errors should arise from the use of the same readings at another if the

index has been adjusted relatively to the screws. As a matter of fact such adjustments are made from time to time. This probably explains why Mr. Gill has come to a different conclusion to myself with respect to the existence of strained readings when the screws were new. I have not the records before me, but I know that I carefully looked into the matter at the time; but as the strain becomes important only when extreme readings are used, it is impossible for me now to say whether such erroneous readings began at 0^r, or -1^r, or -2^r; all I assert is, that within the limits of range of screws occasionally, but, I presume, accidentally, used, there were some indications in 1856–1860 of exactly the same character as that shown by the curve resulting from the observations made in 1877. In exactly the same way there is visible wear in the screws of the Radcliffe Transit Circle, but experiments made over the threads in constant use give such results as those which follow, which include errors of screws and of observations:—

1884, July 10.

Reading of the Declination Micrometer.	Resulting Nadir Point.	Correction to Mean.
	° ′ ″	″
15·1	218 20 4·28	+0·15
16·1	4·47	−0·04
17·05	4·64	−0·21
18·3	4·34	+0·09
19·1	4·48	−0·05
20·3	4·26	+0·17
21·1	4·27	+0·16
22·2	4·56	−0·13
23·3	4·37	+0·06
24·1	4·65	−0·22
25·2	4·44	−0·01

1^r of the micrometer = $32''{\cdot}045$.

Similar results have been obtained in other yearly examinations. The index has been adjusted, so that if negative readings be not taken, the errors are confined within the limits indicated by these observations, which are quantities within which I cannot answer for our work. The assistants are instructed, as they were at the Cape, to carefully avoid negative readings, and I can hardly understand how Mr. Gill can have persuaded himself that screws worn only to the extent indicated by the Cape Nadir observations in 1877 could have led to serious systematic errors in the catalogued results. That such is quite impossible can be seen by an inspection of his Tables VII. and VIII., when it is remembered that the observations for Nadir, runs, and of stars were confined within the limits adopted in the Cape work. But it is

quite possible to give a perfectly independent proof of the non-existence of any serious systematic errors due to screw-wear.

The Cape Transit Circle was brought into regular use in 1856; and during the years 1856 to 1860 a very considerable number of observations were made of the stars which have been regularly observed at Greenwich since Bradley's time. These observations were reduced whilst I was at the Cape, and are contained in the Cape Catalogue for 1860. The N.P.D. of the Cape Catalogue for 1860 can be assumed to be independent of any serious errors due to the wear of the screws which were at that time new. Since the proper motions of these stars can be determined with some approach to accuracy from observations perfectly independent of the Cape results, we can bring up the N.P.D.'s from 1860 to 1880 with some accuracy without in the slightest degree diminishing any systematic discordances which may exist between the N.P.D.'s of the two Cape Catalogues. I have therefore selected from the Cape Catalogues 1860 and 1880 all the stars whose N.P.D.'s are fixed by at least ten observations in the 1860 Catalogue, and three observations in the 1880 Catalogue, and which have the proper motions in N.P.D., referred to the adopted precession constant, determinable with some approach to accuracy from a comparison between Bradley's observations, or in two cases Piazzi's, and recent Greenwich observations. The N.P.D. of the Cape Catalogue for 1860 are brought up to 1880 with Peters' constant of precession and the adopted proper motions, and the differences taken between these results and those contained in the Cape Catalogue for 1880.

The differences will be affected by at least three independent sources of error.

(1) There will be the error of the N.P.D. given in the Cape Catalogue 1860; I shall certainly not over-estimate the probable error due to this cause by taking

$$e_{1860} = 0''.1.$$

(2) There will be the combined effects of error in the precession constant and adopted proper motion for twenty years. As this cannot be less than $0''.1$, and will be about one-sixth of that due to the relative errors of Bradley's N.P.D. and the recent Greenwich observations, I cannot over estimate the probable error by taking

$$e_m = 0''.2.$$

(3) There will be the probable error of the N.P.D. of the Cape Catalogue of 1880. As there are generally only three or four observations employed in fixing the N.P.D., the probable error, independently of any possible error due to screw wear, will be about

$$e_{1880} = 0''.25.$$

We shall therefore have for the probable error of the computed differences 1860—1880 on the supposition that there are no systematic errors due to screw-wear

$$\overline{pe}| = \sqrt{\overline{0{\cdot}1}|^2 + \overline{0{\cdot}2}|^2 + \overline{0{\cdot}25}|^2} = 0''{\cdot}33.$$

But as these screw-errors, if they exist, must increase the probable error due to mere ordinary chance errors of observing, we shall have, when the probable error due to the screw-wear is taken $= x$

$$\overline{pe}| = \sqrt{\overline{0{\cdot}1}|^2 + \overline{0{\cdot}2}|^2 + \overline{0{\cdot}25}|^2 + x^2}.$$

If, therefore, x could be taken $= 1''$, we should have

$$\overline{pe}| = 1''{\cdot}055.$$

If x could be taken $= 0''{\cdot}5$

$$\overline{pe}| = 0''{\cdot}60.$$

If Mr. Gill does not mean to assert that the Cape N.P.D's are affected by error to $0''{\cdot}5$ from the cause indicated, then I think his paper should not have been written: but even if x could be taken at $0''{\cdot}25$ we should still have

$$\overline{pe}| = 0''{\cdot}42.$$

Now a direct computation of the probable error from the observed differences gives

$$\overline{pe}| = 0''{\cdot}28.$$

This would show that x is really insensible, and that no serious errors can have affected the N.P.D. observations contained in the Cape Catalogue for 1880 due to any such cause as screw-wear.

I append the comparisons between the two Catalogues from which the probable error above given has been deduced.

The agreement between the results, allowing for the few observations by which the N.P.D. of the 1880 Catalogue were fixed, is exceedingly good. There are only two cases out of the 92 comparisons in which the difference between the two Catalogues amounts to a second of arc. The mean excess of the N.P.D. of the 1880 Catalogue is only $+0''{\cdot}06$, the range of N.P.D. being between 51° and 123°, whilst the co-latitude determined from the observations 1856–1860 was

$$123^\circ\ 56'\ 3''{\cdot}56,$$

that found from the more recent observations and included in the Cape Catalogue 1880, was

$$123^\circ\ 56'\ 3''{\cdot}41.$$

I have in the Introduction to the 1880 Catalogue given comparisons between the Cape and Greenwich results, the mean discordance being 0″·31.

There does not, therefore, appear any such indication of constant error as might be inferred from Mr. Gill's remarks.

I hope that Mr. Gill will be better advised than to apply empirical corrections to the North Polar Distances of the Cape Catalogue for 1880. It is quite impossible for him to obtain the true corrections due to any errors which may have existed. The runs are an essential part of the reductions. If the screws had unfortunately been sufficiently worn to prevent reliable readings being taken at any part of the threads in regular use, then most certainly the threads in use for the run determinations could not have been trusted. But as proved from the experiments made during the progress of the work, the effects of screw-wear are so small that the systematic errors due to this cause are certainly less than the probable errors of mere observations in the catalogued results.

Name of Star.	Proper Motion in N.P.D.	Residual Errors N.P.D. −	Residual Errors N.P.D. +	No. of Obs. in Cape Cat. 1860.	No. of Obs. in Cape Cat. 1880.
	″	″	″		
γ Pegasi	+0·011	−0·41		33	7
12 Ceti	+0·012		+0·48	13	9
β Ceti	−0·025	−0·10		122	3
δ Piscium	+0·048		+0·01	12	3
ε Piscium	−0·023		+0·11	34	5
θ Ceti	+0·220		+0·39	42	4
η Piscium	+0·007		+0·43	24	5
ν Piscium	−0·002		+0·03	16	4
β Arietis	+0·118		+0·25	30	3
α Arietis	+0·151	−0·24		38	5
67 Ceti	+0·110		+0·02	28	4
ξ² Ceti	+0·016		+0·32	13	4
α Ceti	+0·086	−0·16		31	5
δ Arietis	+0·002		+0·36	33	3
γ′ Eridani	+0·096		+0·37	30	4
o′ Eridani	−0·080		+0·94	29	3
α Tauri	+0·192	−0·06		103	4
ε Leporis	+0·072	−0·16		26	7
β Orionis	+0·006		+0·09	109	5
β Tauri	+0·181	−0·29		35	3
δ Orionis	+0·005		+0·14	35	5
α Columbæ	+0·045	−0·21		39	7

Name of Star.	Proper Motion in N.P.D.	Residual Errors N.P.D. −	+	No. of Obs. in Cape Cat. 1860.	No. of Obs. in Cape Cat. 1880.
	″	″	″		
α Orionis	−0·007	−0·17		90	3
ζ Canis Maj.	+0·005		+0·16	10	3
γ Geminor.	+0·048	−0·13		17	3
ε Canis Maj.	+0·013	−0·32		70	4
δ Geminor.	+0·016		+0·52	31	3
δ Cancri	+0·036		+0·79	11	6
15 Argûs	−0·059	−0·42		49	6
η Cancri	+0·054		+0·35	27	3
ε Hydræ	+0·053	−0·09		19	3
α Hydræ	−0·030		+0·27	67	6
π Leonis	+0·022		+0·65	27	5
α Leonis	−0·012	−0·31		88	3
χ Leonis	+0·043	−1·10		43	3
δ Crateris	−0·183	−0·19		71	3
τ Leonis	+0·021		+0·73	16	3
υ Leonis	−0·035		+0·16	22	3
β Leonis	+0·119	−0·21		14	3
ε Corvi	−0·020	−0·36		19	3
β Corvi	+0·066	−0·30		98	3
θ Virginis	+0·041		+0·54	26	7
α Virginis	+0·038		+0·35	118	4
ζ Virginis	−0·059		+0·80	11	4
α Boötis	+1·977	−0·27		37	4
20 Libræ	+0·032		+0·04	15	3
β Libræ	+0·031		+0·35	42	3
α Serpentis	−0·034	−0·26		17	3
β Scorpii	+0·038		+0·01	77	4
δ Ophiuchi	+0·143		+0·49	24	4
σ Scorpii	+0·026	−0·47		14	3
α Scorpii	+0·037	−0·45		139	13
τ Scorpii	+0·043	−0·63		20	3
θ Ophiuchi	+0·029	−0·52		53	4
α Ophiuchi	+0·218	−0·34		20	3
Stone 9795	+0·039		+0·22	11	3
μ Sagittarii	+0·012	−0·36		72	3
δ Sagittarii	+0·027		+0·14	29	3
ε Sagittarii	+0·130		+0·61	19	4
λ Sagittarii	+0·224	−0·36		20	5

Name of Star.	Proper Motion in N.P.D.	Residual Errors N.P.D. −	Residual Errors N.P.D. +	No. of Obs. in Cape Cat. 1860.	No of Obs. in Cape Cat. 1880.
	"	"	"		
α Lyræ	−0·272		+0·06	16	3
φ Sagittarii	+0·008	−0·53		24	3
σ Sagittarii	+0·077	−0·02		40	3
ζ Sagittarii	+0·006	−0·49		23	3
τ Sagittarii	+0·251	−0·08		18	3
ψ Sagittarii	+0·029	−0·28		14	4
ω Aquilæ	−0·022		+0·41	24	3
δ Aquilæ	−0·076	−0·02		36	5
h^2 Sagittarii	+0·027		+0·19	46	3
γ Aquilæ	+0·008		+0·13	12	4
α Aquilæ	−0·380	−0·95		108	5
b Sagittarii	+0·036		+0·05	13	3
c Sagittarii	−0·016	−0·26		21	5
α^2 Capricorni	0·000		+0·85	86	3
ρ Capricorni	+0·020	−0·08		46	4
ψ Capricorni	+0·162	−0·16		15	4
θ Capricorni	+0·075		+0·39	12	3
ι Capricorni	−0·004		+0·41	16	3
β Aquarii	+0·016		+0·27	95	7
ε Pegasi	+0·006		+0·33	21	3
δ Capricorni	+0·313		+0·13	21	3
α Aquarii	+0·014	−0·20		33	10
θ Aquarii	+0·025		+0·62	35	3
σ Aquarii	+0·030		+1·08	12	5
η Aquarii	+0·040		+0·27	22	7
γ Piscis Aust.	(0·000)		(+0·01)	10	3
α Piscis Aust.	+0·171		+0·26	123	6
φ Aquarii	+0·177		+0·33	10	3
γ Piscium	−0·009		+0·31	26	3
κ Piscium	+0·111	−0·08		36	9
ι Piscium	+0·443		+0·66	23	9
δ Sculptoris	+0·103		+0·02	16	3
ω Piscium	+0·104	−0·20		27	7

On account of the variability in their proper motions I have not included *Sirius* and *Procyon*.

It is perhaps desirable that some notice should be taken of the statement which Mr. Gill has made in the Introduction to the Cape Catalogue for 1850 with respect to the differences

between the Right Ascensions of this Catalogue and those of the Cape Catalogue for 1880 when reduced to a common epoch. Mr. Gill appears to consider that these differences indicate systematic errors in the Cape Catalogue for 1880 due to variation in the place of collimation. I must remark, however, that materials do not exist for an accurate determination of the proper motions of the southern stars with reference to the adopted precession constant; and we cannot bring up places for a period of thirty, or even twenty, years with sufficient accuracy to justify attempts to base discussions of instrumental systematic errors upon differences of observed places when thus compared. Such differences may, of course, be due to instrumental defects, but they may be principally due to uncorrected proper motion. But the mean difference found by Mr. Gill of $0^s.06$ divided by 30 years gives only a yearly change of $0^s.002$, and this is within the possible, and I should suppose probable, errors of the determination of our precession constant. I have compared the Melbourne Right Ascensions made in 1875 with the Cape Observations 1870–1880; and in this comparison we are not much concerned with proper motions. The result, which I find appears clearly to indicate that the differences between the Cape Catalogues 1850 and 1880, are not due to either lateral refraction or any systematic variation in the plane of collimation of the Cape Transit Circle, unless the Melbourne instrument is affected by sensibly equal errors. The Melbourne clock errors are apparently based on the Greenwich standard places, and as the Cape results are also based on the same places, the Right Ascensions of the clock stars must therefore agree, and I have not included their differences in the following result. But between 124° and 170° N.P.D. I have found 46 stars which were observed at Melbourne in 1875, and whose Right Ascensions are contained in the Cape Catalogue 1880. Instead of finding the Cape R.A. too small, as would appear to be the case from Mr. Gill's comparisons with the Cape Catalogue for 1850, I find the difference reaches the limit of two-tenths only in one case, when a single observation only was used for Melbourne R.A., and that the mean excess of the R.A. Cape 1880, over R.A. Melbourne 1875, is only $+0^s.02$. I do not wish to assert that the Cape results are free from systematic errors, but I am certain that if such exist they are small, and that such systematic errors in Right Ascension as may exist will be chiefly dependent upon the adopted Right Ascensions of the clock stars.

Addendum.

There are some statements of Mr. Gill's on pages 80 and 81 to which, on seeing his paper in print, it appears desirable that I should make some reply.

1. The screw constraint was not due to dirt. It was present, whether the screws were clean and fresh oiled or not, when certain threads were brought into play.

2. "Occasional notes such as 'screws turned stiffly,' followed soon after by a note that 'the screws were cleaned,' and there are no more notes about stiffness of the screws for a long time," merely show that the Cape screws, like other screws, occasionally required cleaning, and were cleaned.

3. Mr. Gill's attempted proof of progressive wear between 1856–57 and 1872–73 consists merely in showing that the runs were about $0^{r}\cdot014$ greater in 1872–73 than in 1856–57, and an *assumption* that there were no adjustments of the microscopes between those dates. If Mr. Gill had given the runs after June 1873, he could have proved, on the same assumptions, that the screws had worn in the opposite direction; for the runs after June 1873 are about $0^{r}\cdot028$ *less* than those in 1857–58. Mr. Gill must have seen that such changes are principally due to adjustments; and he might have known that as the microscopes A and B had to be taken off in 1873 to allow the supplementary microscopes *a* and *b* to be dismounted, as is stated in the Cape Results, 1873, page xvi.; and as these microscopes *a* and *b* had been mounted by me soon after my arrival at the Cape, 1870–71, in order to determine the division-errors of the circle, the microscopes A and B must, at that time, have also been dismounted in order to mount the microscopes *a* and *b*. If, therefore, we suppose that the adjustments of the microscopes had not been disturbed after 1857–58 till I arrived at the Cape, a most improbable assumption, they certainly had been disturbed before the readings 1872–73.

4. An inspection of the observations made by me in 1877 shows clearly enough that no continuous curve can be drawn to represent the errors of the screws; the observations between $5^{r}\cdot1$ and $5^{r}\cdot8$ fall on a straight line, and there is less discordance than $0''\cdot5$ between $5^{r}\cdot1$ and $10^{r}\cdot1$. The fact brought out by these observations is that the errors changed *per saltum* when the parts of the screws which corresponded to the readings about my 0^{r}, or Mr. Gill's 5^{r}, were brought into play. If, therefore, it was wished to make accurate observations with these screws, it could be done by avoiding the use of these threads about 5^{r}, and in no other way, and this is the course which I have followed. This is clearly shown by Mr. Gill's extracts from my notes, for it will be seen that even in 1872–73 negative readings were most carefully avoided. The indices of the microscopes were adjusted so that the defective threads of the screws could not be employed in the observations so long as negative readings were avoided; and the assistants were cautioned against the use of negative readings. If I found that such readings for runs were accidentally made, they were no doubt rejected because it was known that they must be defective, and ought not to have been made; and if at any time I had reason to suppose that the defective threads were from slight changes again coming into use, the indices were readjusted to avoid the further use of these defective threads. An inspection of the results of the

observations made in 1877 shows that with these precautions the effects of screw errors must have been confined within very small limits even in individual observations, and in the results of three or four observations must be practically insensible, and this result is confirmed by the comparison which I have given between the Cape Catalogue 1860 and the Cape Catalogue 1880. The larger errors which appear in Mr. Gill's Tables VII. and VIII. have nothing to do with the systematic errors of the Cape Catalogue 1880, for the simple reason that the threads of the screws to which they apply were not used in the work.

Mr. Gill's idea appears to be that I was bound to make observations over the whole range of the screws, whether the threads were defective or the screws under constraint or not, and then to attempt to determine the errors of these screws and to apply corrections to the results. I preferred to avoid the large errors altogether, and I have done so. Every attempt to carry out Mr. Gill's ideas into practice with the Cape screws would have ended in a disastrous failure. The change of error is so rapid about the 0^r (or Mr. Gill's 5^r) that the errors of the screws could not be determined with any great accuracy, or applied with any certainty subject to such shifts of adjustments as are inevitable in practical work. But whether Mr. Gill's ideas might have been practically carried out or not, I was certainly entitled to carry out my own ideas, which I knew would lead to results of very considerable accuracy. I have carried them out, and I am satisfied with the result.

Note on the Descriptions of two Stars in Ptolemy's Catalogue. By E. B. Knobel.

In the first printed edition of the *Almagest*, which is that published in Latin by Liechtenstein at Venice in 1515, the descriptions of the 8th star in *Scorpio* (*α Scorpii*) and the 2nd star in *Orion* (*α Orionis*) are as follows:—

8. *Scorpio.* "Media earum quæ *tendit ad rapinam* quæ dicitur Cor Scorpionis."
2. *Orion.* "Lucida quæ est super humerum dextrum et ipsa *tendit ad rapinam* quia * appropinquat ad terram in humero Orionis."

Baily remarks in his compiled edition of *Ptolemy's Catalogue*, "There is a singular expression in the edition of Liechtenstein that I am unable to explain. It first occurs in the constellation *Scorpio*, and is repeated in the constellation *Orion*, where the star is described as "tendens ad rapinam."

It is well known that the Liechtenstein *Almagest* is derived

* Baily translates the abbreviation in Liechtenstein as "quæ," but Mr. Scott, Assistant-Keeper of MSS. British Museum, tells me it is undoubtedly "quia."

from Arabic sources. There is abundant internal evidence to prove this; notably in Dictio VII. cap. i., where Arabic names are given to stars, which in the Greek *Almagest* are without names; the proper name Hipparchus is spelt "Abrachis," after the manner of the Arabs, and in the Catalogue many Arabic names are given to the stars and constellations.

I have, however, recently made a close comparison between this printed edition and three Latin MS. *Almagests* of the fourteenth and fifteenth centuries, which are copies of the translation from the Arabic by Gerard of Cremona (A.D. 1114–1187); and from the numerous passages compared being verbatim the same, and particularly from the same blunders and mistakes being common to them all, I think there can be no doubt whatever that the Liechtenstein *Almagest* is simply the printed edition of Gerard of Cremona's translation. Weidler makes the following remark about it. "Sed interpretis nomen non adscribitur nec in præfatione et epilogo memoratur. Collata vero utraque versione apparet hanc Venetam ex Arabico traductam fuisse, et a Trapezuntiana permultum differre."*

The MSS. referred to are the following:—

British Museum, Sloane MS., 2795. Date, circa 1300, possibly earlier.

British Museum, Burney MS., 275. Date, circa 1387.

Latin MS., No. 148–9, belonging to the Earl of Crawford and Balcarres. Date, sæc. XV.

The descriptions of the two stars in question in these three MSS. and the Liechtenstein *Almagest*, are verbatim the same, with the exception that the printed edition alone adds to one of them the words "quia appropinquat ad terram in humero Orionis."

Thinking that some light might possibly be thrown upon the meaning of the sentence "tendens ad rapinam" by examining the original Arabic, I have consulted and obtained extracts from four different Arabic MSS. found in the British Museum, the Bodleian Library, and the Library of the India Office. These MSS. are:—

British Museum, Additional MSS., 7475. *Almagest*, date A.H. 615=A.D. 1218. This MS. is written in a very cursive character, with a lamentable neglect of diacritical points, which renders it very difficult to decipher.

Bodleian Library, Pococke 369 (Uri 888). *Almagest*, date A.H. 799=A.D. 1396.

British Museum, Additional MSS., 7488. "Al Sūfi, Description of the Stars." Date, sæc. XV. or XVI. A fairly well written MS., with very good drawings of the constellations.

India Office Library, No. 2389. "Al Sūfi, Description of the Stars."

* Baily says "the name of the translator of the Liechtenstein *Almagest* not known, nor is it stated whence the MS. was obtained."

The last-named MS. has been kindly examined for me by Dr. J. W. Redhouse, who has taken great trouble to elucidate and solve a difficulty in the translation.

The following descriptions of these stars comprise all the original MSS. and works I have been able to examine:—

8th Star in Scorpio.

1. Greek *Almagest.*
   ὁ μέσος αὐτῶν καὶ ὑπόκιρρος καλούμενος ἀντάρης.
2. Latin *Almagest* from Greek (Trapezuntius).
   Media ipsarum et subruffa quæ vocatur Antares.
3. Latin *Almagest* from Arabic (Gerard of Cremona).
   Media earum quæ tendit ad rapinam quæ dicitur Cor Scorpionis.
4. Arabic *Almagest.* Brit. Mus. Add. MSS., 7475.

الكوكب الوسط منها و هو قلب العقرب و هو شمعى و يسمي بالرومي انطرس

The middle star of them, and it is *Cor Scorpionis*, and it is wax-like, and is named in Greek *Antares.*

5. Arabic *Almagest.* Bibl. Bodl. Pococke, 369.

الوسط منها الذي الحوصي و هو قلب العقرب

The middle one of them, which (is) ? and it is *Cor Scorpionis.*

6. Al Sūfi. Arabic MS. Brit. Mus. Add. MSS., 7488.

الوسط منها الذي يضرب الي الحوض و يقال لم قلب العقرب

The middle one of them, which inclines to ? and is named *Cor Scorpionis.*

7. Al Sūfi. Arabic MS. India Office, No. 2389.

الوسط منها الذي يضرب الي الحرض و يقال له قلب العقرب

(Nearly identical with Brit. Mus. MS.)

8. Al Sūfi. Schjellerup's translation.
   Leur mitoyenne qui tire sur le rouge يضرب الي الخوصي nommée قلب العقرب *le cœur du Scorpion.*
9. Ulugh Beigh. Hyde's translation from Persian.
   Media trium quæ magna est ac rufa. Kalb Al Akrab.

2nd Star in Orion.

1. Greek *Almagest.*
   ὁ ἐπὶ τοῦ δεξιοῦ ὤμου λαμπρὸς ὑπόκιρρος.
2. Latin *Almagest* from Greek (Trapezuntius).
   Splendida quæ in humero dextro et est subruffa.

3. Latin *Almagest*, from Arabic (Gerard of Cremona).
   "Lucida quæ est super humerum dextrum et ipsa tendit ad rapinam." Liechtenstein's printed edition adds, "quia appropinquat ad terram in humero Orionis."
4. Arabic *Almagest*. Brit. Mus. Add. MSS. 7475.
   الكوكب النضي الشمعي الذي علي المنكب اليمن
   The bright star wax-like, which is upon the right shoulder.
5. Arabic *Almagest*. Bibl. Bodl., Pococke, 369.
   النير الذي علي المنكب اليمن و هو يغرر * الي الحوصي
   * (Copyist's error for يضرب)
   (Identical with Al Sūfi.)
6. Al Sūfi. Arabic MS. Brit. Mus. Add. MSS. 7488.
   النير الذي علي المنكب الايمن و هو يضرب الي الحوض
   The bright (star) which is on the right shoulder inclining to ?
7. Al Sūfi. Arabic MS. India Office.
   النير الذي علي المنكب الايمن و هو يضرب الي الحوض
   (Identical with Brit. Mus. MS.)
8. Al Sūfi, Schjellerup's translation.
   La brillante qui est sur l'épaule droite et qui tire sur le rouge يضرب الي الخوصي
9. Ulugh Beigh. Hyde's translation.
   Stella lucida in humero dextro quæ ad rubedinem vergit.

All these descriptions, with the exception of No. 3 by Gerard of Cremona, contain some word which is intended, probably, as a translation of the Greek ὑπόκιῤῥος, to express the *colour* of the star.

But there is a marked and singular difference in the Arabic authorities.

In the British Museum *Almagest* the four principal red stars of Ptolemy, *α Tauri*, *β Geminorum*, *α Scorpii*, and *α Orionis*, described by Ptolemy as ὑπόκιῤῥος, are designated شمعي (shamäie), which means "like wax," from شمع (wax).* This is a satisfactory explanation of the enigmatical words "et est cerea," which Liechtenstein uses in the descriptions of the 14th star of *Taurus* (*α Tauri*), and the 2nd star in *Gemini* (*β Geminorum*), and which have been always a puzzle to students of the *Almagest*.

In the Bodleian *Almagest*, however, the corresponding word

* It should be noted that the Bodleian *Almagest* describes the colour of three of these stars as well as *Sirius*, by the sentence يضرب الي الحوصي

is الحوصي, and in this MS. and the two MSS. of Al Sūfi as well as in Schjellerup's translation we have the following variations:—

الحرة	الحرض	الحوض	الخوصي	الحوصي
El harah.	El harad.	El hūd.	El chūsi.	El hūsi.

The general resemblance of all these words suggests errors in copying.

The word الحوصي, el hūsi, in the Bodleian *Almagest*, has no meaning, and must be an error of the scribe. It is not found in any of the other MSS.

Prof. Schjellerup, in his Al Sūfi, gives Ptolemy's correct description to the stars in question, and also to the red star *α Tauri*, but he appends the Arabic word الخوصي, which he translates "rouge," or "rougeâtre." Dr. Rieu, the Keeper of Oriental MSS. at the British Museum, and Dr. Redhouse inform me there is no such Arabic word implying colour. In fact, Prof. Schjellerup translates the word as it ought to be, his Arabic MS. having an untranslatable word.

In the British Museum MS. of Al Sūfi the word ὑπόκιρρος in *β Geminorum* and *Antares* is in each case translated الحوض, el hūd, and the same word is used in the India Office MS. in the descriptions of the 2nd star in *Gemini* and the 2nd in *Orion*. There appears to be no known meaning to this word implying colour.

Dr. Redhouse considers that the word الحرض, el harad, which he finds in the description of the 8th star in *Scorpio* (and which I have also found in the British Museum MS. of Al Sūfi in the description of the 2nd star in *Orion*), is the real word, of which the others are only copyists' errors. He gives the meaning of الحرض, el harad, as "sallowness of complexion, pallor," which is in fair agreement with ὑπόκιρρος, "somewhat yellow;" and also with the expression "et est cerea," "wax-like;" the identical word in Arabic for which شمعي is found in the British Museum *Almagest*.

This explanation may be the true one, but there is the fifth word, الحرة, el harah, which I find in the British Museum MS. of Al Sūfi in the description of the 14th star in *Taurus*, and which Dr. Redhouse finds also used for the same star in the India Office MS. He infers that this is meant for الحمرة, el hamra, "redness." The word الحرة is derived from حر, meaning "heat," "fierce," "fiery," and this meaning is clearly applicable to the stars in question. It is quite obvious that all the words are intended to express the colour of the star.

It is by no means clear what the word was which Gerard of

Cremona translated as "rapina," the Arabic for which النثر not resembling any of the variations given. The arrangement and construction of his sentence closely resembles the Bodleian *Almagest*, and is the exact translation (except this one word) of the several copies of Al Sūfi. The verb in these MSS. is يضرب, which corresponds exactly with "tendens" in Gerard of Cremona, and "vergit" in Hyde's Ulugh Beigh. It is not an improbable suggestion that Gerard of Cremona found in his MS. the same untranslatable word which I have found in the MSS. quoted; and one case being the principal star of *Scorpio*, "the accursed constellation and the baleful source of war and discord," and the other, the principal star of *Orion*, who was held to "portend tempests and misfortune," he translated it by the word "rapine," having the *astrological* significance of these constellations and of these particular stars. And, as has been suggested to me by Dr. Garnett, Liechtenstein's addition of "quia appropinquat ad terram in humero Orionis," was a continuation of the astrological idea erroneously started by the mistranslation by Gerard of Cremona of العحوصي, or one of the words given above.

With regard to the British Museum Arabic *Almagest* it appears to differ from the Bodleian *Almagest*, so as to indicate a different translation from the Greek.

I have taken out from this MS. the positions of stars in many of the constellations, and have found a very singular mistake made by the original translator of the MS. from the Greek. The number 60 is expressed in Arabic by the letter س, Seen, but it is curious that the letter ص, Sād, which signifies 90, has always been put for the س. So a translator would record the latitudes of many stars as 90 and odd degrees instead of 60 and odd.

This mistake is rather inexplicable, but it appears that the numerical value of the letters of the alphabet is remembered among the Arabs by certain fictitious words as follows:—

هوز Huz, 7, 6, 5,	ابجد Abjad, 4, 3, 2, 1,
كلمن Kalman, 50, 40, 30, 20,	حطي Hati, 10, 9, 8,
قرشت Karshat, 400, 300, 200, 100,	سعفص Sāfas, 90, 80, 70, 60,
ضظغ Dathagh, 1000, 900, 800,	ثخذ Thakhath, 700, 600, 500,

In the case in question, the scribe, wanting the character for 60, would remember the word "sāfas," which begins and ends with an S sound, and he has taken the last S instead of the first.

Less easy is it to explain a more curious mistake which occurs in both Latin MSS. of the *Almagest* of Gerard of Cremona at the British Museum, and with precisely the same stars as the above error in the Arabic *Almagest.* The latitudes of 34 stars in the Catalogue are given as 300 and odd degrees instead of 60 and odd * degrees. Here the translator must have confounded the س, Seen, =60, with the ش, Sheen, =300, and given the numerical value of the latter letter to the former.

1885, *January* 7.

Note on the Periodic Time of α Centauri.
By A. M. W. Downing, M.A.

In the *Monthly Notices* for November last there is an interesting paper by Mr. Powell on the periodic time of *α Centauri*, in which he contends that the period of this celebrated binary—for our knowledge of the orbital motion of which we are so much indebted to his own observations—cannot, in all probability, be less than 86 or 87 years. Into the reasons which have induced Mr. Powell to come to this conclusion I do not propose to enter on the present occasion, and will content myself with saying that it appears to me that the only test of an orbit is to compare it with *observations*; and that, as far as I can judge, a period of about 76 years will stand this test as well as can be reasonably expected, taking into account the insufficient means of observation employed for the earlier measures, and the difficulty of making accurate observations, on account of the proximity of the stars, in some of the later ones. In order to show this agreement in some extreme cases, I have compared the position-angles computed from the orbit, published in the *Monthly Notices* for March 1884, with the individual measures made before Herschel's time, and also with a set of measures made last year by Mr. Tebbutt (*Observatory*, vol. vii. p. 296) subsequently to the date of publication of the elements to which I refer.

Epoch.	Observer.	Observed Pos. Angle.	Observed – Computed.
1752·2	Lacaille	218°·7	+4°·19
1822·0	Fallows	209·6	−1·00
1824·0	Brisbane	215·4	+3·77
1826·01	Dunlop	213·2	+0·52
1830·01	Johnson	215·0	+0·10
1831·00	Taylor	215·9	+0·41
1832·16	„	216·4	+0·18
1884·533	Tebbutt	199·80	−0·46

* In the Sloane MS. the impossibility of such latitudes seems to have occurred to the scribe, who has endeavoured to correct them by erasing the cypher, and so making them 30 and odd degrees, but in no case has the correct latitude been given.

I may remark that there is no use in forcing an agreement with Lacaille's position-angle (at all events within 5° or so), as I find that a change of 3″ in the difference of Declination of the components changes the position-angle more than 5°; and considering the small number of observations on which Lacaille's places depend, the quantity mentioned above is probably well within the limits of error. Brisbane's position-angle appears to be erroneous. The agreement in the other cases is close, and I see no evidence that a period differing much from 76·222 years is required to satisfy the observations.

Note on Prof. Pritchard's Comparison of the Light Transmitted by Refracting and Reflecting Telescopes. By W. S. Franks.

There are a few points in Prof. Pritchard's remarks, at the last meeting of the Society, that I should like to see cleared up. At the outset he seems to infer that nothing has been done in the way of careful comparison, between reflectors and refractors, since the time of Dr. Robinson, on whose results he depends largely.

Possibly no photometric comparison had been previously attempted; but, certainly, careful eye-estimates have been made by various observers of the relative light-ratio of the two classes of telescopes, mounted side by side, and directed upon identical objects, the results being published in some of the scientific journals. A cursory inspection of the last twenty volumes of the *English Mechanic* will afford ample evidence in support of this statement.

Dr. Robinson's conditions may be very well so far as they go, but they do not go far enough. Two very important points are ignored—the relative foci of the telescopes, and their magnifying powers. Now I note that Prof. Pritchard stated, in answer to Mr. Rand Capron (*Observatory* report) that the focal lengths of the O.G. and mirrors were the same. This, surely, is a slip, for, according to the best of my knowledge, the particulars are as follows:—

		Aperture.	Focus.
a	Grubb refractor	$12\frac{1}{3}$ inches.	15 feet.
b	De la Rue reflector	13 „	10 „
c	With reflector	13 „	9 „ (?)

(The last I am not certain of, but have given the usual focus of Mr. With's 13-in. specula.)

Therefore, the angles of convergence between 15 feet and 9 or 10 feet focus will be widely different. From this it follows that to get equivalent magnifying powers we must use very different eyepieces; and the eyepiece on the refractor would be

formed with lenses of shallower curves, consequently thinner and more transparent, than would be possible with the eyepiece producing an equal amplification on the reflector.

Such comparisons, however carefully made, possess but little value unless the following conditions be attended to—1. The foci must be identical, and the angles of convergence therefore similar; 2, the *same* eyepiece must be alternately used on each instrument, for even eyepieces are not infallible; 3, the instruments must be placed side by side, under precisely similar atmospheric conditions, and directed on the same object; 4, the observer, it is scarcely necessary to add, must be the same. I cannot allow that these conditions were rigidly fulfilled in Prof. Pritchard's comparison. Moreover, I do not consider the principle of extinction by a coloured wedge at all applicable in settling this vexed question. I have tested this on some double stars, and was rather astonished to find such a difference between the relative magnitudes of the components, as seen with the wedge and without it. But if a wedge be used, the stars selected should be *white*. Out of Prof. Pritchard's list only *two* are really white stars, the rest being more or less coloured. [There is one star I fail to recognise, *g Pegasi*, but, as it is a star of 2·5 mag., perhaps Prof. Pritchard will give its better known Bayer synonym.].

I am aware that Prof. Pritchard states that "he had not entered upon the general question of comparing achromatic object-glasses with mirrors," although, at the same time, he admits that the particular telescopes used "may be regarded as representative instruments." Nevertheless, I do not see how he can escape the logical conclusion that the general is involved in the particular. In all these comparisons I have spoken of the telescopes were regarded as complete instruments, not merely as separate object-glasses or specula. If the latter were the case, we should have also to consider another factor—the secondary mirror or prism used with all reflectors, save the Herschelian. But most practical observers wish to know the ultimate effect of their telescopes as such, caring less about the theoretical difference between O.G. and mirror *per se*. And, evidently, in comparing two telescopes together, it is not fair to use a different eyepiece on each; for how are we to distinguish between effects due to the O.G. or mirror from those produced by the eyepiece alone?

Another statement, on p. 31, *Monthly Notices*, I must take exception to. It is there stated that "it has long been known that the reflective power of silver exceeds that of speculum metal, and this also no doubt is the case (though possibly not to an equal extent) with chemically deposited silver on glass." I now refer to the sentence used parenthetically. The deposit of silver on glass is chemically *pure*, and, with a dense film, takes a perfectly black polish, capable of the highest reflective power; whilst ordinary silver is always alloyed, and, though increasing

in hardness, its reflective properties are thereby somewhat impaired. In connection with this, I may call attention to a statement by Mr. De la Rue, in the discussion which followed the reading of the paper, to the effect that "speculum metal reflects more actinic rays than silver on glass." If this be so, how is it that speculum metal mirrors impart a distinctly *redder* tone to the image than silver on glass?

Much as I would welcome any addition to our knowledge on the interesting, though controversial, subject of the light-ratio between reflectors and refractors, I am afraid we are doomed to wait a little longer before the question shall be finally set at rest.

Leicester:
1884, *Dec.* 13.

Observations of Stars occulted by the Moon during the Eclipse of Oct. 4, 1884, *made at Clapham.* By Edmund J. Spitta.

General Observations.—The sky was cloudless, but owing to the glare of the Moon no stars before No. 74 of the Pulkova list could be recognised with the 10-inch Calver Reflector, power 60. During totality the Moon was, generally speaking, exceedingly faint—indeed, at times barely visible to the naked eye—and presented none of the coppery colour usual on these occasions. It was bluish at the lower edge as seen in the inverting telescope about 10 o'clock, when the other portion seemed brighter than at any time. No markings were plain enough to be recognised.

An assistant called half seconds by the chronometer, time being observed an hour previous, and the observation reduced for collimation and azimuth errors, &c. G.M.T. was obtained by allowing 33 sec. W., taken from the 6-inch Ordnance chart. Owing to the observations being taken without a chronograph, no attempt was made for closer notation of the contacts; indeed, the nature of the phenomena does not seem to permit of greater accuracy—hence the similitude of the decimals in the corrected times.

Star. Pulk. List.	Mag.	G.M.T. Disappearance.	G.M.T. Reappearance.
74	9·3		9 50 4·83
76	10	9 16 52·83	
81	9·5	9 33 33·83	10 38 7·83
82	10	Observed, but badly noted.	10 15 52·83

Star. Pulk. List	Mag.	G.M.T. Disappearance.	G.M.T. Reappearance.
85	10	9 24 40·33	10 31 37·83
94	9–10	10 6 50·83	
95	9·5	10 12 10·33	
106	10	10 36 44·83	
108	9–10	10 37 32·83	

Note of an Observation of Saturn, Nov. 23, 1884. By Edmund J. Spitta.

Whilst viewing *Saturn*, Nov. 23, with the 10-inch Calver Reflector, my attention was directed, by indirect vision, to an unusual illumination of the edge of the crape ring at the western or following elongation. On applying the *occulting eyepiece* and hiding the ball I found the brightness unmistakable; it lasted some little time, and then the ring resumed its normal aspect. The brightness was ill-defined all the while, but it gave me the impression I was looking at a star through the crape ring, or possibly some satellite whose orbit must lie *within* the rings between them and the ball. The observation was so unexpected that I cannot state its exact duration, but I believe it lasted about 10 minutes, time 11 25 to 11 35 ± 1 min. G.M.T. Mr. Bryant has computed the exact position of ball and rings, and I have looked over several catalogues, but only find one star near enough to allow of the possibility of occultation. My friend, Mr. Coleman, however, has carefully, and he says under the most favourable conditions, examined the computed position, and finds four small stars, one of them the 11th magnitude, which lies, as nearly as he can judge, in the exact path of *Saturn*. His observation was made near the meridian.

I do not for one moment state I feel positive this brightness was due to a star, but its short duration and the finding of four in or about the path are facts pointing thereto; I merely note the observation, acting up to the motto of the Society.

Clapham Common.

Observations of Comet c 1884 (Wolf), made by the Rev. Ad. Müller, at Stonyhurst College Observatory, with the 8-inch Telescope and Ring-Micrometer.

(*Communicated by the Rev. S. J. Perry, F.R.S.*)

1884.	Stonyhurst Mean Solar Time.	R.A. ☌−✱	Decl. ☌−✱	No. of Comp.	Apparent R.A.	Log. of Par. Factors.	Apparent Decl.	Log. of Par. Factors.	Star.
	h m s	m s	′ ″		h m s		° ′ ″		
Nov. 10	6 8 23	+1 39·65	− 4 59·9	3	22 30 22·37	$8{\cdot}956_n$	−0 4 28·4	0·852	1
13	6 24 15	−1 43·19	+18 46·6	5	22 37 21·12	$8{\cdot}782_n$	−1 1 16·5	0·857	2
14	6 25 34	+0 38·62	+ 2 27·5	5	22 39 42·90	$8{\cdot}750_n$	−1 18 25·7	0·859	3
19	9 48 3	−0 42·75	+23 10·7	3	22 51 37·69	9·380	−2 37 22·5	0·862	4
20	6 55 35	+1 57·62	+10 38·9	5	22 54 18·09	7·498	−2 49 54·4	0·867	5
21	6 26 56	+1 0·00	+18 23·9	4	22 56 59·85	$8{\cdot}587_n$	−2 59 38·7	0·868	6
22	9 32 21	−3 38·85	−13 15·9	3	22 59 29·88	9·356	−3 17 41·0	0·865	7
23	6 4 5	−4 3·89	+14 53·8	3	23 1 11·51	$8{\cdot}830_n$	−3 28 25·2	0·870	8
24	6 15 31	−1 33·68	+ 2 32·8	3	23 3 41·62	$8{\cdot}683_n$	−3 40 46·3	0·871	9
24	7 15 18	−1 27·72	+ 2 5·8	3	23 3 47·58	8·631	−3 41 13·3	0·871	10

Dark Field illuminating Micrometer, with two cross wires at Right Angles to each other, and inclined 45° to the Parallel of Declination.

1884.	Stonyhurst Mean Solar Time.	R.A. ☌−✱	Decl. ☌−✱	No. of Comp.	Apparent R.A.	Log. of Par. Factors.	Apparent Decl.	Log. of Par. Factors.	Star.
	h m s	m s	′ ″		h m s		° ′ ″		
Dec. 9	7 3 49	+0 29·97	+ 6 32·0	5	23 42 28·48	8·751	−5 45 57·0	0·880	11
11	9 53 11	−3 18·50	+ 9 41·2	4	23 47 56·06	9·453	−5 55 51·7	0·869	12
14	9 58 47	−1 39·55	− 3 56·1	3	23 55 44·74	9·457	−6 7 4·1	0·868	13
15	8 37 16	+0 45·03	− 3 36·7	4	23 58 9·32	9·300	−6 9 44·3	0·857	14

Assumed Mean Places for 1884·0 of the Comparison Stars with Reductions to Apparent Place for the Night of Observation.

Star.	R.A. 1884·0 + Reduct.	Decl. 1884·0 + Reduct.	Authority.	Remarks.
	h m s s	° ′ ″ ″		
1	22 28 39·56 + 3·16	+0 0 5·8 + 25·7	Lalande 44096	Comet well defined.
2	22 39 1·16 + 3·15	−1 20 28·2 + 25·1	" 44495	Good sky. Comet fainter.
3	22 39 1·16 + 3·12	−1 20 28·2 + 25·0	" 44495	Fine and clear.
4	22 52 17·31 + 3·13	−3 0 57·2 + 24·0	Weisse (hora 22) 1052	Star of comparison rather doubtful.
5	22 52 17·31 + 3·16	−3 0 57·2 + 23·9	" 1052	Bright clear sky. Nucleus fainter.
6	22 55 56·71 + 3·14	−3 18 26·2 + 23·6	Lalande 45036	Good.
7	23 3 5·56 + 3·17	−3 4 48·7 + 23·6	" 45297	Satisfactory.
8	23 5 12·23 + 3·17	−3 43 42·1 + 23·1	" 45360	Definition good.
9	23 5 12·23 + 3·16	−3 43 42·1 + 23·0	" 45360	Observation difficult; Moon and mist.
10	23 5 12·23 + 3·16	−3 43 42·1 + 23·0	" 45360	Observation more satisfactory.
11	23 41 55·38 + 3·13	−5 52 49·2 + 20·2	Weisse (hora 23) 821	Nucleus very poorly defined.
12	23 51 11·39 + 3·17	−6 5 52·8 + 19·9	Lalande 46940	Wind high. Clouds passing. Observation very difficult.
13	23 57 21·13 + 3·16	−6 6 27·2 + 19·2	Weisse (hora 23) 1152	Nucleus invisible. Measures made with difficulty.
14	23 57 21·13 + 3·16	−6 6 27·2 + 19·1	" 1152	Observation good.

The observations of this comet were commenced on October 12, and continued up to the present time on every available occasion. Owing to the faintness of the comet it was impossible to use the bright-field micrometer. Hence the observations of October 12, 14, 15, and 19 were made with the square-bar micrometer by taking transits, the declinations being read at the circle of the Equatorial. As, however, such positions are not sufficiently exact, they have not been inserted in the preceding list.

During the whole period of the observations the comet has been a sufficiently distinguishable object, consisting of a round luminous patch, having a diameter of from 1′ to 1′·7, with a nucleus situated somewhat towards the N.W. of the centre. This bright patch sometimes presented the appearance of having luminous projections, emanating from the side opposite to the nucleus. This was especially the case on November 10 and 14 when they assumed the appearance of a V.

The first series of measures were made with a ring-micrometer, sufficiently well constructed at the Observatory. The second series, dating from December 9, were made with a bright-wire micrometer, the wires being at 45° to the diurnal motion. The wires were placed very exactly in position by means of the position-circle of the telescope, which is read by two verniers.

Observations of Occultations of Stars by the Moon, and of Phenomena of Jupiter's Satellites, made at the Royal Observatory, Greenwich, in the year 1884.

(*Communicated by the Astronomer Royal.*)

Day of Obs.		Phenomenon.	Telesc.	Power.	Moon's Limb.	Mean Solar Time of Observation.	Obs.
Feb.	6 (*a*)	Disapp. 120 Tauri	E. Eq.	140	Dark	8 59 6·30	H.
Mar.	6	Disapp. λ Geminorum	E. Eq.	70	„	10 9 31·89	H.
	6	Disapp. λ Geminorum	Altaz.	100	„	10 9 31·99	A. D.
May	8 (*b*)	Disapp. λ Virginis	E. Eq.	140	„	9 13 15·42	H.
	30 (*c*)	Disapp. 16 Sextantis	Simms' Eq.	220	„	10 17 47·21	A. D.
Dec.	30	Disapp. 115 Tauri	E. Eq.	140	„	8 28 20·56	H. T.

(*a*) Disappearance instantaneous. (*b*) Some cloud about the Moon.
(*c*) Disappearance instantaneous.

Phenomena of Jupiter's Satellites.

Day of Obs.	Sat.	Phenomenon.		Telesc.	Power.	Mean Solar Time of Observation.	Mean Solar Time of N.A.	Obs.
						h m s	h m s	
1884, Jan. 11	II.	Tr. Ing.	Bisection	E. Eq.	70	8 22 3	8 25 0	H.
			Last contact	"	"	8 25 48		
24	I.	Tr. Ing.	First contact	"	140	6 48 51	6 49 0	L.
			Last contact	"	"	6 53 1		
	I.	Tr. Egr.	First contact	"	"	9 5 9	9 9 0	L.
			Last contact	"	"	9 10 48		
Feb. 12 (*a*)	II.	Tr. Ing.	First contact	"	70	6 27 35	6 31 0	H.
			Last contact	"	"	6 34 29		
	II.	Tr. Egr.	First contact	"	"	9 25 46	9 25 0	H.
			Last contact	"	"	9 30 36		
15	I.	Occ. D.	Last seen	"	"	9 9 53	9 9 0	A. P.
	I.	Ecl. R.	First seen	"	"	12 5 44	12 5 28	A. P.
21 (*b*)	II.	Ecl. R.	First seen	"	140	8 16 17	8 16 9	L.
			Full brightness	"	"	8 16 32		
26	II.	Tr. Ing.	First contact	"	"	11 9 37	11 10 0	L.
			Last contact	"	"	11 12 51		
29	I.	Occ. D.	Bisection	"	70	12 41 37	12 43 0	H.
			Last seen	"	"	12 44 9		

Day of Obs.	Sat.	Phenomenon.	Telesc.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Obs.
1884, Mar. 4 (*c*)	II.	Tr. Ing. First contact	E. Eq.	210	13 30 25	13 32 0	H.
		Last contact	,,	,,	13 34 0		
(*d*)	IV.	Ecl. R. First seen	,,	70	14 12 15	14 15 42	H.
		Full brightness	,,	,,	14 15 33		
6 (*e*)	II.	Ecl. R. First seen	,,	210	13 27 18	13 27 27	A. D.
9 (*f*)	III.	Occ. R. Bisection	S.E. Eq.	310	7 36 25		W. C.
		Last contact	,,	,,	7 37 40	7 41 0	,,
(*g*)		Clear of planet	E. Eq.	70	7 42 23		T.
(*h*)	III.	Ecl. D. First contact	S.E. Eq.	310	8 18 10		W. C.
		Bisection	,,	,,	8 20 40		,,
		Last seen	,,	,,	8 26 25	8 23 44	,,
		Began to fade	Simms' Eq.	220	8 17 38		L.
		= Sat. I. in brightness	,,	,,	8 21 42		,,
		Last seen	,,	,,	8 24 57		,,
10	I.	Tr. Egr. First contact	E. Eq.	70	8 35 59	8 38 0	H.
		Last contact	,,	,,	8 40 18		
12 (*i*)	IV.	Tr. Ing. First contact	Simms' Eq.	220	7 43 5		W. C.
		Bisection	,,	,,	7 47 50		,,
		Last contact	,,	,,	7 53 50	7 41 0	,,
(*k*)		First contact	E. Eq.	210	7 41 18		A. D.
		Last contact	,,	,,	7 52 46		,,

Day of Obs.		Sat.	Phenomenon.		Telesc.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Obs.
1884, Mar. 12	(*l*)	IV.	Tr. Egr.	First contact	E. Eq.	210	11 57 6	12 8 0	A. D.
				Last contact	"	"	12 12 3		
15		II.	Tr. Egr.	Bisection	Simms' Eq.	220	8 1 7	8 5 0	T.
				Last contact	"	"	8 3 21		
21	(*m*)	IV.	Ecl. R.	First seen	S.E. Eq.	310	8 14 59	8 22 19	M.
	(*n*)			First seen	Simms' Eq.	220	8 19 28		W. C.
22		II.	Tr. Egr.	Last contact	E. Eq.	210	10 34 21	10 34 0	A. D.
24		II.	Ecl. R.	First seen	Simms' Eq.	220	7 56 2	7 56 6	T.
				Full brightness	"	"	7 57 32		
		I.	Tr. Ing.	First contact	"	"	10 1 27	9 59 0	T.
				Last contact	"	"	10 5 56		
	(*o*)	I.	Tr. Egr.	Last contact	"	"	12 20 34	12 19 0	T.
29		II.	Tr. Ing.	Last contact	E. Eq.	70	10 5 37	10 11 0	H.
31		II.	Ecl. R.	First seen	"	140	10 32 1	10 31 26	L.
				Full brightness	"	"	10 33 58		"
				First seen	Simms' Eq.	220	10 32 19		H.
				Full brightness	"	"	10 34 23		"
		I.	Tr. Ing.	First contact	"	"	11 48 10	11 52 0	"
				Bisection	"	"	11 50 40		"
				Last contact	"	"	11 54 59		"
				First contact	E. Eq.	140	11 51 15		L.
				Last contact	"	"	11 55 25		"

Day of Obs.	Sat.	Phenomenon.		Telesc.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Obs.
1884, Apr. 1 (*p*)	I.	Ecl. R.	First seen	E. Eq.	210	12 34 21	12 34 13	T.
2	I.	Tr. Egr.	First contact	„	70	8 37 12	8 39 0	H.
			Last contact	„	„	8 43 11		
3 (*q*)	III.	Tr. Egr.	Bisection	Simms' Eq.	220	8 48 55		A. D.
			Last contact	„	„	8 52 40	8 50 0	„
			Last contact	E. Eq.	210	8 52 53		T.
7 (*r*)	II.	Occ. D.	First contact	Simms' Eq.	220	7 41 6	7 43 0	A. D.
			Last contact	„	„	7 45 6		
9 (*s*)	I.	Tr. Ing.	First contact	E. Eq.	210	8 14 18	8 13 0	T.
			Last contact	„	„	8 20 27		
	I.	Tr. Egr.	Last contact	„	„	10 34 5	10 33 0	T.
10 (*t*)	I.	Ecl. R.;	First seen	Simms' Eq.	220	8 58 26	8 58 36	M.
			First seen	E. Eq.	70	8 58 39		H.
	III.	Tr. Ing.	First contact	„	„	9 5 4		„
			Last contact	„	„	9 13 53		„
			First contact	Simms' Eq.	220	9 9 56	9 12 0	M.
			Bisection	„	„	9 14 36		„
			Last contact	„	„	9 18 16		„
16 (*q*)	I.	Tr. Ing.	Last contact	„	„	10 12 50	10 8 0	H.

Day of Obs.	Sat.	Phenomenon.		Telesc.	Power.	Mean Solar Time of Observation h m s	Mean Solar Time of N.A. h m s	Obs.
1884, Apr. 21 (*b*)	III.	Ecl. D.	Began to fade	Simms' Eq.	220	8 19 15		M.
			Half brightness	„	„	8 21 45		„
			Last seen	„	„	8 25 10	8 23 10	„
			Last seen	E. Eq.	140	8 22 59		S. D.
	III.	Ecl. R.	First seen	„	„	11 48 26		„
(*u*)			First seen	S.E. Eq.	310	11 54 31		M.
			Half brightness	„	„	11 56 46	11 53 55	„
			Full brightness	„	„	11 59 26		„
23 (*v*)	IV.	Occ. R.	First seen	„	220	8 14 21		„
			Bisection	„	„	8 18 24	8 15 0	„
(*r*)			Last contact	E. Eq.	210	8 19 11		A. D.
	I.	Tr. Ing.	First contact		„	12 2 19		
			Bisection	„	„	12 4 34	12 3 0	„
			Last contact	„	„	12 7 39		
24 (*w*)	I.	Occ. D.	First contact	Simms' Eq.	220	9 12 14		L.
			First contact	E. Eq.	140	9 9 48	9 15 0	H.
28	III.	Occ. R.	First seen	„	„	10 45 43		L.
			Last contact	„	„	10 47 58		„
			First seen	Simms' Eq.	220	10 45 50	10 49 0	H.
			Last contact	„	„	10 50 25		„
30	II.	Tr. Ing.	Last contact	E. Eq.	140	9 59 11	10 0 0	„
May 3	I.	Ecl. R.	First seen	„	210	9 14 15		A. D.
			Full brightness	„	„	9 17 2	9 13 53	

Day of Obs.	Sat.	Phenomenon.		Telesc.	Power.	Mean Solar Time of Observation. h m s	Mean Solar Time of N.A. h m s	Obs.
1884, May 9	I.	Tr. Ing.	First contact	E. Eq.	210	10 25 35		
			Bisection	”	”	10 28 44	10 26 0	B.
			Last contact	”	”	10 32 19		
10	IV.	Ecl. D.	Began to fade	”	140	10 1 33		L.
			Bisection	”	”	10 3 3		”
(h)			Last seen	”	”	10 5 7	10 2 25	”
			Last seen	Simms' Eq.	220	10 5 13		W. C.
(x)			Last seen	S.E. Eq.	”	10 6 50		M.
10 (y)	I.	Ecl. R.	First seen	”	”	11 9 25		”
			Bisection	”	”	11 11 41		”
			Full brightness	”	”	11 13 53	11 9 21	”
			First seen	E. Eq.	140	11 9 47		L.
			Full brightness	”	”	11 11 57		”
23 (c)	III.	Tr. Ing.	Last contact	”	”	9 56 45	9 55 0	A. P.
26	I.	Ecl. R.	First seen	Simms' Eq.	220	9 29 15		A. D.
			Full brightness	”	”	9 32 9	9 29 2	”
			First seen	E. Eq.	140	9 29 41		B.
Nov. 24 (z)	I.	Ecl. D.	Began to fade	”	70	14 10 18	14 10 48	H.
			Last seen	”	”	14 10 57		
Dec. 6	III.	Ecl. D.	Last seen	Simms' Eq.	220	15 47 52	15 43 55	H. T.
(h)			Last seen	E. Eq,	140	15 47 3		L.

Notes.

(*a*) Slightly cloudy.
(*b*) Observation considered very good.
(*c*) *Jupiter's* limb indistinct.
(*d*) Very distinctly seen.
(*e*) Satellite appeared at full brightness four minutes after recorded time.
(*f*) Satellite not seen till 15^s before time recorded for bisection; sky hazy; definition poor.
(*g*) Satellite just clear of planet; cloudy.
(*h*) Satellite had become extremely faint at $8^h\ 26^m\ 10^s$, but was still visible by glimpses for 15^s longer. Definition good; edge of *Jupiter's* shadow seen sharp and distinct on the satellite. Time for first contact probably too late. Time of bisection fairly exact.
(*i*) The last contact had certainly not occurred at $7^h\ 53^m\ 30^s$, and was long past at $7^h\ 54^m\ 50^s$; clouds passing.
(*k*) Clouded over immediately after time noted for last contact, but observer considered that the last contact had then taken place.
(*l*) Planet very unsteady; satellite quite clear of *Jupiter* 2^m after time of last contact.
(*m*) *Jupiter* frequently lost in cloud, but at the moment when the satellite was first seen the planet was shining very brilliantly. The satellite was so faint at the first glimpse, and was so long before it showed a sensible disk, that there can be no doubt that the first instant of reappearance was well caught. At $8^h\ 20^m\ 49^s$ the satellite was at half brightness, at $8^h\ 24^m\ 19^s \pm$ at ¾ brightness. Clouds intervened before these times, and the planet was lost in cloud before the satellite had gained its full brightness. When glimpsed for a few seconds about $8^h\ 25^m\ 19^s$ the satellite was not even then so bright as Satellite II.
(*n*) Extremely faint when first glimpsed; steadily and very distinctly visible 30^s later. Sky clouded over about $8^h\ 24^m$.
(*o*) *Jupiter* diffused; sky very thick and hazy.
(*p*) Definition bad; sky thick.
(*q*) Cloudy at first contact.
(*r*) Cloudy; observation uncertain.
(*s*) Definition very bad; sky foggy.
(*t*) Satellite at half brightness $1^m\ 15^s$ after recorded time, and at full brightness $2^m\ 20^s$ after recorded time.
(*u*) *Jupiter* low down and in some amount of mist and smoke; image very unsteady.
(*v*) Considered a good observation. *Jupiter* in mist and cloud constantly passing, but just for a moment or two the planet was well seen with the minutest point of the satellite projecting from the limb. Observation of bisection very rough; *Jupiter* faint. Clouds concealed the planet before the satellite was clear of the limb.
(*w*) Observation not good; satellite very faint; cloudy. *Jupiter* clear of cloud at $9^h\ 20^s$, when there was no sign of the satellite.
(*x*) Considered a very good observation. Satellite steadily held though exceedingly faint to moment of disappearance. Sky very clear; images fairly steady.
(*y*) Considered a very good observation. Sky very clear, but images very unsteady.
(*z*) Satellite seemed to reappear for an instant about 10^s later.

The clear aperture of the object-glass of the S.E. Equatorial is 12·8 inches; of the E. Equatorial, $6\frac{3}{4}$ inches; of the Altazimuth, 4 inches; and of the Simms' Equatorial, 6 inches.

The initials W. C., H. T., A. D., M., T., L., H., A. P., B., and S. D., are those of Mr. Christie, Mr. Turner, Mr. Downing, Mr. Maunder, Mr. Thackeray, Mr. Lewis, Mr. Hollis, Mr. Pead, Mr. Bennett, and Mr. Dolman.

Occultations of Stars by the Moon, and Phenomena of the Satellites of Jupiter and Saturn, observed at Mr. Edward Crossley's Observatory, Bermerside, Halifax, in the year 1884, *with the* $9\frac{1}{3}$*-inch Cooke Refractor.* By Joseph Gledhill, F.R.A.S.

Lunar Occultations.

			G.M.T. h m s		
1884. Oct.	4	No. 61	9 22 42	R.	Power 62: bad sky.
		No. 63	9 35 55	R.	Mr. Crossley was at the telescope and Mr. Gledhill at the chronometer.
		No. 76	9 28 2	R.	
		No. 85	9 25 52	D.	
		No. 82	9 25 40	D.	
			10 37 28	D.	Small double star; angle about 140° from N.
			10 45 36	D.	Small star; angle about 45°.
			9 44 30	D.	„ „ 170°.
	5	*o* Piscium	9 8 0		Near approach; distance from nearest point of limb 3′ 14″. Power 60.
	12	*a* Cancri	18 1 33	D.	Power 240.
Nov.	5	111 Tauri	9 9 5	D.	Power 62.
		115 Tauri	10 2 7	D.	„
			10 46 40	R.	„
	7	68 Gemin.	11 15 59	D.	„
			12 16 19	R.	„
	9	*h* Leonis	13 59 59	D.	Thin cloud near Moon.
			15 4 35	R.	Clear sky. Power 62.
	11	76 Leonis	The star escaped occultation.		
	25	*θ* Aquarii	5 39 7	D.	Bad sky. Power 62.
			6 52 12	R.	„ „
	29	*o* Piscium	The star escaped occultation.		
Dec.	3	B.A.C. 1930	Watched from 10.10 till 10.51; no star seen near Moon.		

Phenomena of Jupiter's Satellites.

					G.M.T. h m s	N.A. h m s	
1884, Jan.	7	I.	Ec. D.	Just gone	11 21 25	11 21 14	Fair definition.
	11	II.	Sh. I.			8 0 0	Shadow very faint; not well seen till 8.15 P.M.
		II.	Tr. I.	Outer contact	8 22 ±	8 25 0	Good definition now and then.
				Bisection	8 24 ±		
				Inner contact	8 26 ±		
		II.	Sh. E.	First contact	10 50 ±	10 54 0	Definition poor now.
		II.	Tr. E.	,,	11 13 ±	11 19 0	Better definition.
				Bisection	11 15 ±		
				Second contact	11 18 ±		
	15	I.	Tr. I.	Inner contact	10 41 ±	10 39 0	Much cloud.
	19	III.	Oc. R.	Just off?	8 2 ±	8 1 0	Badly seen through cloud.
	20	II.	Oc. R.	,,	8 36 ±	8 35 0	No trace of Sat. at 8^h 33^m.
	25	I.	Ec. R.	First seen	6 21 40	6 21 35	Seen through thin cloud.
	26	III.	Oc. D.	First contact	7 40 ±	7 41 0	Stormy.
				Bisection	7 42 ±		
				Just gone	7 45 ±		
Feb.	2	III.	Oc. D.	First contact	10 58 ±	10 58 0	Poor definition.
				Bisection	11 1 ±		
	2	III.		Just gone	11 3 ±		
	6	III.	Sh. E.	Certainly off	6 2 ±	6 0 0	Cloudy.
		I.	Oc. D.	Half gone	13 0 ±	12 58 0	,,
	8	I.	Ec. R.	First seen	10 10 44	10 10 42	Seen through thin cloud.

				G.M.T. h m s	N.A. h m s	
1884, Feb.	9	I.	Tr. E. Inner contact	7 2 ±	7 3 0	Stormy.
		I.	Sh. E. Off	7 33 ±	7 34 0	„
	21	II.	Ec. R. First seen	8 16 8	8 16 9	Observed at the Observatory of James S. Cooke Esq., Gomersal, near Leeds. 7-in. refractor.
			Fully bright	8 19 ±		
	24	I.	Ec. R. First seen	8 29 4	8 29 10	Much motion.
			Full disc	8 33 ±		
Mar.	1	I.	Tr. I. First contact	10 2 26	10 2 0	Much cloud. Mr. Crossley at telescope.
			Bisection	10 4 6		„ „
			Inner contact	10 5 51		„ „
		I.	Sh. I. Just within	11 0 ±	10 58 0	„
	8	II.	Sh. E. Inner contact	7 37 ±	7 42 0	„
			Half off	7 39 ±		
	9	III.	Ec. D. Fading	8 21 0	8 23 44	Cloud obscured planet.
	10	I.	Tr. I. First contact	6 19 30	6 18 0	
			Inner contact	6 24 0		Uncertain.
	15	II.	Tr. E. Inner contact	7 59 30	8 5 0	Good sky.
			Bisection	8 1 0		
			Outer contact	8 3 0		
		II.	Sh. I. Bisection	7 25 0	7 24 0	E. C. at telescope.
			Just within	7 26 0		„
		II.	Sh. E. Inner contact	10 14 0	10 19 0	
	16	III.	Oc. D. First contact	7 44 30	7 47 0	

				G.M.T. h m s	N.A. h m s	
1884. Mar. 16	I.	Oc. D.	First contact	11 49 0	10 49 0	
			Half gone	11 50 30		
			Just gone	11 52 0		
	III.	Oc. R.	First seen	11 15 0	11 20 0	
			Half off	11 16 0		
			Just off	11 17 30		Uncertain.
	III.	Ec. D.	Fading ?	12 18 0		
			Fading	12 20 0		
			Half bright ?	12 22 30		
			Just gone	12 27 1	12 24 7	
18	I.	Ec. R.	First seen	8 43 6	8 43 27	Clouds pass.
			Half bright	8 45 0		
			Full disc	8 47 0		
21	IV.	Ec. R.	First seen	8 16 34		
			Still faint	8 20 0	8 22 19	
			Not half disc	8 22 0		
			Full disc ?	8 30 0		
24	II.	Ec. R.	First seen	7 50 6	7 56 6	Clouds.
	I.	Tr. I.	First contact	9 59 0	9 59 0	
			Second contact	10 4 0		
25	I.	Ec. R.	First seen	10 39 1	10 38 49	E. C. Perhaps a few seconds late.
	I.	Oc. D.	First contact	7 6 30	7 8 0	
			Gone	7 10 0		

				G.M.T.	N.A.	
				h m s	h m s	
1884, Mar. 31	II.	Ec. R.	First seen	10 31 38	10 31 26	Probably 10s late.
			Half disc	10 34 0		Uncertain.
			Full	10 37 0		"
Apr. 2	I.	Tr. E.	Just off	8 40 0	8 39 0	Clouds.
	I.	Sh. E.	Inner contact	10 0 0	9 55 0	"
	I.	Sh. I.	"	7 37 0	7 35 0	Uncertain.
7	II.	Oc. D.	Outer contact	7 42 0	7 43 0	
			Half gone	7 44 0		
			Just gone	7 45 30		
Apr. 7	II.	Ec. R.	First seen	13 6 41	13 6 40	
9	I.	Tr. I.	Outer contact	8 16 0	8 13 0	Bad definition.
			Bisection	8 18 0		Uncertain.
			Inner contact	8 19 30		
	I.	Sh. I.	"	9 31 0	9 30	
	I.	Tr. E.	"	10 29 0	10 33 0	
			Bisection	10 32 30		
			Outer contact	10 34 30		
	I.	Sh. E.	Inner contact	11 45 0	11 50 0	Uncertain.
May 10	IV.	Ec. D.	Fading	9 58 0		
			Just gone	10 4 10	10 2 25	
	I.	Ec. R.	First seen	11 9 50	11 9 11	
			Full disc?	11 12 0		
18	I.	Tr. E.	Half off	9 12 0	9 14 0	

				G.M.T.	N.A.	
				h m s	h m s	
1884, May 18	I.	Tr. E.	Just off	9 15 0		
26	I.	Ec. R.	First seen	9 29 5	9 29 2	
			Half full ?	9 31 0		
			Full	9 32 30		
Nov. 8	I.	Ec. D.	Fading fast	15 56 23	15 56 35	Clouds.
9	I.	Tr. I.	Outer contact	14 15 30	14 17 0	
			Inner contact	14 18 ±		Planet very low.
11	III.	Sh. I.	Just within	13 43 ±	13 41 0	Good sky.
	III.	Sh. E.	,,	17 23 ±	17 24 0	
13	II.	Ec. D.	Last seen	18 15 34	18 15 26	Bad sky.
15	II.	Sh. I.	Just within	13 9 ±	13 10 0	
	II.	Tr. I.	First contact	15 39 ±	15 41 0	Bad sky.
	II.	Sh. E.	Just within	16 6 0	16 7 0	
	I.	Ec. D.	Fading	17 48 0	17 49 36	
			Just gone	17 50 6		
16	I.	Sh. I.	,,	14 54 0	14 57 0	Uncertain: cloud.
	I.	Tr. I.	First contact	16 10 0	16 12 0	
			Last contact	16 13 0		
17	I.	Oc. R.	First seen	15 49 0	15 50 0	No definition.
22	II.	Sh. I.	Just on disc	15 44 0	15 43 0	Uncertain.
	III.	Oc. R.	First seen	16 27 0	16 28 0	Much cloud.
24	I.	Ec. D.	Fading	14 8 0	14 10 48	Cloudy.
29	III.	Ec. R.	First seen	15 18 57	15 19 19	Misty.

Observations of the Elongations and Conjunctions of the Satellites of Saturn.

Aperture $9\frac{1}{3}$ inches; power 240.

October 6, 1884.—Much cloud often; bad definition.
Enceladus, S.; $13^h\ 10^m$, not on line; $13^h\ 40^m$, near; $13^h\ 50^m$, on line? $14^h\ 0^m$, past.
Rhea, N.; $13^h\ 0^m$, just on line? clouded.

October 7 1884.—*Tethys*, E.; $15^h\ 0^m$, not up; $15^h\ 5^m$, up? $15^h\ 7^m$, up? $15^h\ 10^m$, past.
Dione, S.; $19^h\ 30^m$, not up; $19^h\ 40^m$, not up? $19^h\ 50^m$, on line; $20^h\ 0^m$, past.

October 14, 1884.—*Rhea*, elongation E.; good definition; $10^h\ 45^m$, G.M.T., not up; $10^h\ 50^m$, nearly up; $10^h\ 55^m$, on the web; $11^h\ 0^m$, past? $11^h\ 5^m$, certainly past.

October 19, 1884.—*Dione*, E.; definition bad; $11^h\ 30^m$, not up; $11^h\ 35^m$, nearly on line? probably on it; $11^h\ 40^m$, certainly past.

October 20, 1884.—*Enceladus*, E.; bad definition; $15^h\ 50^m$, near the web; $15^h\ 54^m$, probably on the web; $15^h\ 58^m$, past? $15^h\ 59^m$, certainly past.

October 28, 1884.—Elongation E. of *Tethys*; $9^h\ 15^m$, not up; $9^h\ 20^m$, near; $9^h\ 25^m$, on line? $9^h\ 30^m$, past? $9^h\ 35$, past.

November 5, 1884.—*Tethys*, N.; bad sky; wind and cloud; $9^h\ 50^m \pm$.

November 7, 1884.—*Enceladus*, conjunction S.; bad sky; clouds; $11^h\ 0^m$, not up; $11^h\ 5^m$, on line? $11^h\ 10^m$, past?

November 11, 1884.—Good definition.
Enceladus, elongation E.; $13^h\ 45^m$, not up; $13^h\ 50^m$, up? $13^h\ 50^m$, on line; $14^h\ 0^m$, past? $14^h\ 5^m$, past.
Mimas, W.; glimpsed now and then; on line, $13^h\ 50^m \pm$.
Rhea, conjunction N.; $15^h\ 40^m$, not up; $15^h\ 45^m$, on line; $15^h\ 50^m$, certainly past.

November 19, 1884.—Good definition; *Tethys* easy; *Rhea* rather difficult.
Tethys, conjunction S.; 13^h, not up, but near; $13^h\ 15^m$, up? $13^h\ 25^m$, up; $13^h\ 30^m$ past.
Rhea, elongation E.; $13^h\ 30^m$, $13^h\ 40^m$, not up; $13^h\ 50^m$, up? $14^h\ 0^m$, up? $14^h\ 10^m$, past.

November 20, 1884.—Bad definition, but plenty of light.

Tethys, N.; $11^h\ 45^m$, $11^h\ 55^m$, not up; $12^h\ 0^m$, up? $12^h\ 5^m$, up? $12^h\ 10^m$ past; $12^h\ 15^m$, past.

Dione, S.; $14^h\ 5^m$, $14^h\ 10^m$, not up; $14^h\ 15^m$, up? $14^h\ 20^m$, up? $14^h\ 25^m$ past.

Rhea, N.; $16^h\ 10^m$, $16^h\ 15^m$, not up; $16^h\ 17^m$, up? $16^h\ 20^m$, up? $16^h\ 24^m$ on line; $16^h\ 30^m$, past. *Enceladus* not seen.

November 22, 1884.—Much cloud at times.

Tethys, N.; $9^h\ 10^m$, not up; $9^h\ 15^m$, near; $9^h\ 17^m$, very near; $9^h\ 19^m$ to $9^h\ 25^m$, up? $9^h\ 30^m$, past? $9^h\ 33^m$, past.

Enceladus, E.; $12^h\ 30^m$, just visible; not up; $12^h\ 40^m$. very near; $12^h\ 42^m$, very near; $12^h\ 45^m$, on line? $12^h\ 50^m$, on line? $13^h\ 0^m$, past? $13^h\ 5^m$ past; well seen at $13^h\ 30^m$. *Mimas* invisible.

November 23, 1884.—$8^h\ 10^m$, two satellites seen at times; one a little past S. conjunction at $8^h\ 10^m$.

November 24, 1844.—Much cloud; *Dione*, N., $16^h\ 47^m$ ±.

November 25, 1884.—*Enceladus*, N.; on web, $13^h\ 49^m$; past $13^h\ 51^m$.

November 26, 1884.—*Mimas* not seen.

Enceladus, E.; very difficult; $15^h\ 34^m$, not up; $15^h\ 40^m$, past.

Dione, E.; $18^h\ 45^m$, not up; $18^h\ 50^m$, on web? clouds passing.

November 27, 1884.—*Dione*, N.; $10^h\ 15^m$, not up; $10^h\ 20^m$, not up; $10^h\ 35^m$, on line? $10^h\ 40^m$, on line? $10^h\ 45^m$, past.

Rhea, S.; $10^h\ 35^m$, $10^h\ 45^m$, not up; $10^h\ 48^m$, up; $10^h\ 49^m$, up; $10^h\ 50^m$ to $11^h\ 0^m$, up; $11^h\ 5^m$, past.

November 28, 1884.—*Enceladus*, N.; $7^h\ 25^m$, not quite up; $7^h\ 30^m$, up? $7^h\ 35^m$, past?

November 29, 1884.—*Rhea*, E.; $11^h\ 0^m$, $11^h\ 10^m$, not up; $11^h\ 20^m$, $11^h\ 25^m$, on line? $11^h\ 30^m$, past? $11^h\ 35^m$, past.

Dione, E.; $12^h\ 15^m$, $12^h\ 20^m$, not up; $12^h\ 25^m$, up? $12^h\ 30^m$, past? $12^h\ 35^m$, past.

Rhea, N.; $16^h\ 50^m$, not up; $16^h\ 55^m$, up; $17^h\ 0^m$, up? $17^h\ 10^m$, past.

December 6, 1884.—*Rhea*, S.; $11^h\ 15^m$, not up; $11^h\ 20^m$, not up; $11^h\ 25^m$, up? yes; $11^h\ 28^m$, past.

December 9, 1884.—*Enceladus*, N.; $6^h\ 20^m$, not up; $6^h\ 40^m$, past; very difficult.

Tethys, N; $8^h\ 45^m$, near; $8^h\ 50^m$, up; $8^h\ 50^m$, past? $8^h\ 55^m$, past.

December 15, 1884.—*Enceladus*, S; on line, $10^h\ 15^m$?
Rhea, N.; $11^h\ 50^m$, not up? $11^h\ 55^m$, not up? $12^h\ 0^m$, up? $12^h\ 10^m$, up? $12^h\ 15^m$, past? $12^h\ 20^m$, past.

Method of Observation.—Usually the horizontal section of the eye was placed parallel to the longer diameter of the rings, and a judgment formed as to when the satellite was at its elongation E. or W., or on an imaginary line passing through the centre of the ball from N. to S. Occasionally the web of the micrometer was used to aid the estimation, and when definition was very good, the straight edge of a diaphragm between the lenses of the eyepiece was sometimes used.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. FEBRUARY 13, 1885. No. 4.

EDWIN DUNKIN, F.R.S., President, in the Chair.

Rev. Edward Allen, M.A., Castlechurch Vicarage, near Stafford;
Rev. John Burgess, 90 Cheriton Road, Folkestone; and
P. Edward Dove, 9 Argyll Street, Regent Street, W.;

were balloted for and duly elected Fellows of the Society.

REPORT OF THE COUNCIL TO THE SIXTY-FIFTH ANNUAL GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Non-resi	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1883 ...	226	371	2	3	602	49	1	652
Since elected	+3	+23	...	...	...	+3	...	...
Deceased	−3	−9	−1	...	...	−3	...	...
Resigned	...	−5	...	...	...	...	...	...
Expelled	...	−1	...	...	...	...	...	...
Removals	+1	−1	...	...	...	...	...	...
December 31, 1884 ...	227	378	1	3	609	49	1	659

Mr. Common's Account as Treasurer of the Royal

RECEIPTS.

	£ s. d.	£ s. d.
Balance at Bankers', Jan. 1, 1884:	291 9 6	
,, in hand of Assistant Secretary on account of Turnor and Horrox Funds	7 0 2	
,, in hand of Assistant Secretary on Petty Cash account...	10 18 11	
		309 8 7
Half-year's dividend on £7,500 Consols... ...	110 3 2	
,, ,, £5,700 New 3 per cent. Stock	83 14 5	
,, ,, £7,500 Consols... ...	110 3 2	
,, ,, £5,700 New 3 per cent. Stock	83 14 5	
Dividends on £500 Metropolitan Stock	14 14 0	
		402 9 2
Received on account of Subscriptions:		
Arrears	189 0 0	
269 Annual Contributions for 1884 ...	564 18 0	
3 ,, ,, 1885 ...	6 6 0	
22 Admission Fees	46 4 0	
19 First Contributions	32 11 0	
		838 19 0
4 Composition Fees		84 0 0
Sales of Publications:		
At Williams & Norgate's, 1883	28 10 3	
At Society's Rooms, 1884	33 6 3	
		61 16 6
Due to Assistant Secretary on Petty Cash account, Dec. 31, 1884...		4 9 1
		£1,701 2 4

Astronomical Society, from Dec. 31, 1883, *to Dec.* 31, 1884.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	225	0	0			
" " for assistance in editing Society's publications...	50	0	0			
				275	0	0
Income Tax and House Duty				9	3	9
Fire Insurance				7	16	6
Printing: Spottiswoode & Co.	666	3	6			
Engraving, Lithography, &c.	25	0	11			
Computation of Ephemerides in *Monthly Notices*	50	0	0			
				741	4	5
Turnor and Horrox Funds: Purchase of Books for Library	8	12	3			
Binding Books in Library	24	16	2			
				33	8	5
Carpet and rugs for Library				55	19	0
House Expenses	35	3	8			
Wages	26	12	0			
Postage, &c.	58	13	9			
Carriage of parcels, &c.	5	1	1			
Stationery and office expenses	7	17	8			
Expenses of meetings	20	0	0			
Coals and gas	51	4	2			
Sundry fittings, repairs, &c.	8	12	9			
Sundries	4	8	1			
				217	13	2
Lee fund				5	0	0
Mrs. Jackson-Gwilt's annuity				8	19	0
Bankers' commission on cheques					1	0
Balance at bankers', Dec. 31, 1884	338	9	2			
" in hand of Assistant Secretary on account of Turnor and Horrox Funds...	8	7	11			
				346	17	1
				£1,701	2	4

Audited and found correct, Jan. 7, 1885.

ROBT. J. LECKY.
RICHARD INWARDS.

Assets and present property of the Society, January 1, 1885:—

	£	s.	d.	£	s.	d.
Balance at Bankers', Dec. 31, 1884	338	9	2			
„ in hand of Assistant Secretary on account of Turnor and Horrox Funds... ...	8	7	11			
	346	17				
Less due to Assistant Secretary on Petty Cash account	4	9	1	342	8	0
Due on account of subscriptions:						
14 Contributions of 3 years' standing ...	88	4	0			
30 „ 2 „ ...	126	0	0			
60 „ 1 „ ...	126	0	0			
6 Admission fees and first contributions ...	18	18	0			
Due from Messrs. Williams & Norgate for sales of Publications during 1884				38	10	8

£7,500 Consols, including the Lee Fund, the Turnor Fund, and the Horrox Memorial Fund.

£5,700 New 3 per cent. Stock, including Mrs. Jackson-Gwilt's gift (£300).

£500 Metropolitan Board of Works Stock.

Astronomical and other MSS.; Books, Prints, Instruments, and Furniture.

Unsold Publications of the Society.

One Gold Medal.

Report of the Auditors.

We, being two of the duly appointed Auditors, beg to lay before this Annual General Meeting of the Royal Astronomical Society the following Report:—

We have examined the Treasurer's account, and an account of the assets and property of the Society, and have found and certified the same to be correct.

The receipts and expenditure for the past year are as stated in the Treasurer's account. The cash in hand on December 31, 1884, including the balance at the bankers', amounted to 346*l.* 17*s.* 1*d.*

The funded property is the same as at the end of last year.

The books, instruments, and other effects have been examined and found to be in a satisfactory condition, so far as their safe keeping is concerned.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

Robt. J. Lecky.
Richard Inwards.

Stock in hand of volumes of the *Memoirs* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	6	...	XXIX.	413	...
I. Part 2	41	...	XXX.	163	...
II. Part 1	52	...	XXXI.	145	...
II. Part 2	19	...	XXXII.	159	...
III. Part 1	66	1	XXXIII.	166	1
III. Part 2	85	1	XXXIV.	166	6
IV. Part 1	80	3	XXXV.	110	6
IV. Part 2	92	3	XXXVI.	201	10
V.	107	4	XXXVII. Part 1	342	4
VI.	126	3	XXXVII. Part 2	285	4
VII.	150	3	XXXVIII.	279	1
VIII.	128	3	XXXIX. Part 1	251	4
IX.	135	3	XXXIX. Part 2	256	4
X.	148	...	XL.	279	1
XI.	155	...	XLI.	429	1
XII.	162	...	XLII.	244	2
XIII.	165	1	XLIII.	254	1
XIV.	373	3	XLIV.	236	1
XV.	141	...	XLV.	275	2
XVI.	168	1	XLVI.	279	5
XVII.	149	2	XLVII. Part 1	3	...
XVIII.	149	...	XLVII. Part 2	21	...
XIX.	155	...	XLVII. Part 3	2	...
XX.	156	...	XLVII. Part 4	13	...
XXI. Part 1	314	...	XLVII. Part 5	13	...
XXI. Part 2	99	...	XLVII. Part 6	13	...
XXI. 1 & 2 (together)	63	1	XLVII.	300	6
XXII.	157	...	XLVIII. Part 1	460	9
XXIII.	152	...	Index to *Memoirs*	646	1
XXIV.	159	1			
XXV.	170	...			
XXVI.	174	2			
XXVII.	426	...			
XXVIII.	386	...			

Stock in hand of volumes of the *Monthly Notices* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	70	...	XXIV.	23	...
II.	72	...	XXV.	7	...
III.	...	...	XXVI.	9	...
IV.	...	...	XXVII.	3	...
V.	...	...	XXVIII.	71	1
VI.	38	1	XXIX.	52	...
VII.	2	...	XXX.	66	2
VIII.	139	2	XXXI.	97	...
IX.	22	3	XXXII.	117	5
X.	175	1	XXXIII.	102	2
XI.	185	1	XXXIV.	82	2
XII.	11	2	XXXV.	64	1
XIII.	150	3	XXXVI.	32	1
XIV.	109	3	XXXVII.	39	3
XV.	124	2	XXXVIII.	102	1
XVI.	107	2	XXXIX.	100	1
XVII.	136	1	XL.	114	3
XVIII.	166	...	XLI.	115	5
XIX.	57	...	XLII.	122	4
XX.	34	...	XLIII.	128	5
XXI.	17	...	XLIV.	131	10
XXII.	32	...	Index to *Monthly Notices*	582	2
XXIII.	28	...			

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XLIV. no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.

No. 7. The *Smeaton* equatoreal.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatoreal.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatoreal, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection:—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.
„ 29. (3) $4\frac{6}{10}$-inch achromatic telescope, about 5 feet 6 inches focal length; finder; rack motion; double-image micrometer; two other micrometers; object-glass micrometer; one terrestrial and ten astronomical eyepieces, applied by means of two adapters; equatoreal stand, and clock movement.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length; with iron stand, and also Ys for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.
„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

No. 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle, by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

„ 52. (26) Dipping needle, by Robinson.

„ 53. (27) Compass needle, mounted for variation.

No. 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

„ 55. (29) Box of magnetic apparatus.

„ 56. (30) Hassler's reflecting circle, by Troughton; a 10½-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

„ 58. (32) Plane 2⅜-inch speculum, artificial horizon, and stand.

„ 59. (33) 2½-inch circular level horizon, by Dollond.

„ 60. (34) Artificial horizon, roof, and trough; the trough 8¼ by 4½ inches: tripod stand.

„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square: one beam compass.

„ 62. (36) A pentagraph.

„ 63. (37) A noddy.

„ 64. (38) A small Galilean telescope with object-glass of rock crystal.

„ 65. (39) Five levels.

„ 66. (40) 18-inch celestial globe.

„ 67. (41) Varley stand for telescope.

„ 69. (43) Telescope, with the object-glass of rock crystal.

„ 70. Portable equatoreal stand.

„ 71. Portable altazimuth tripod.

„ 72. Four polarimeters.

„ 74. Registering spectroscope, with one large prism.

„ 76. Two five-prism direct-vision spectroscopes.

„ 78. 9¼-inch silvered-glass reflector and stand, by Browning.

„ 79. Spectroscope.

„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.

„ 81. A back-staff, or Davis' quadrant.

„ 82. A nocturnal or star dial.

„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.

„ 84. A Hollis observing chair.

„ 85. Double image micrometer, by Troughton and Simms.

„ 86. 4½-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.

No. 87. $3\frac{1}{2}$-inch Gregorian reflecting telescope with wooden tripod stand.

„ 88. Pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.

„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.

„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.

„ 91. Astronomical time watchcase, by Professor Chevallier.

„ 92. 2-foot protractor, with two moveable arms, and vernier.

„ 93. Beam compass, in box.

„ 94. 2-foot navigation scale.

„ 95. Stand for testing measures of length.

„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.

„ 97. 12-cell Leclanché battery.

„ 98. 2 feet 6 inch navy telescope with object-glass $2\frac{1}{4}$ inches, by Cooke, with portable wooden tripod stand.

„ 99. 12-inch transit instrument, by Fayrer & Son, with level and portable stand.

„ 100. 9-inch transit instrument, with level and iron stand.

„ 101. Small equatoreal sight instrument, by G. Adams, London.

„ 102. Sun-dial, by Troughton.

„ 103. Sun-dial, by Casella.

„ 104. Sun-dial.

„ 105. Box sextant, by Troughton and Simms.

„ 106. Prismatic compass, by Schmalcalder, London.

„ 107. Compass, by C. Earle, Melbourne.

„ 108. Prismatic compass, by Negretti and Zambra.

„ 109. Dipleidoscope, by E. Dent.

„ 110. Abney level, by Elliott.

„ 111. Pocket spectroscope, by Browning.

„ 112. Small brass astrolabe.

„ 113. Double sextant, by Jones.

„ 114. Two models, illustrating the effects of circular motions.

„ 115. A cometarium.

„ 116. A pair of 18-inch globes.

„ 117 } Two old sun-dials.
„ 118 }

No. 119. Specimens of rulings on speculum metal, by Prof. W. A. Rogers, presented by H. J. Chaney, Esq.
„ 120. A 6-prism spectroscope, by Browning, presented by J. D. Perrins, Esq.
„ 121. Improved maximum and minimum thermometer, presented by E. J. Spitta, Esq.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons:—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 22. The *Matthew* equatoreal, to Mr. Brett.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 74. Registering spectroscope, with prism, to Mr. R. J. Lecky.
„ 99. 12-inch transit, to Rev. A. Freeman.

From the *Sheepshanks* collection:—

No. 27. (1) 30-inch transit instrument and stand, to Mr. G. M. Whipple.
„ 29. (3) Clock and equatoreal mounting, to Mr. R. Bryant.
„ 29. (3) Three micrometers, to Mr. E. Ristori.
„ 30. (4) 3¼-inch equatoreal and stand, to Mr. H. Sadler.
„ 31. (5) 2¾-inch telescope and stand, to Mr. E. Ristori.
„ 34. (8) Transit instrument, to Prof. C. Pritchard.
„ 36. (10) 8-inch pillar sextant, to Mr. R. Bryant.
„ 69. (43) Telescope, with rock-crystal object-glass, to Dr. W. Huggins.

No. 29. (3) Telescope, lent to the Transit of *Venus* Committee, and lost in the "City of Brussels," has not yet been replaced.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Dr. Huggins for his researches on the motions of Stars in the line of sight, and on the photographic spectra of Stars and Comets. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

Vol. XLVIII., Part 1, of the *Memoirs* has been published during the year. It contains the following paper:—

Heliometer Determinations of Stellar Parallax in the Southern Hemisphere. By David Gill and W. L. Elkin.

Vol. XLVIII., Part 2, is in the press, and will shortly be published. It will contain the following papers:—

Fourth Catalogue of Micrometrical Measures of Double Stars, made at the Temple Observatory, Rugby. By G. M. Seabroke.

On the Relative Proper Motions of 40 Stars in the *Pleiades*, determined from Micrometric and Meridional Observations. By Prof. C. Pritchard.

Observations of *Mars* at the Opposition of 1884. By E. B. Knobel.

On the Corrections required by Hansen's "Tables de la Lune." By E. Neison.

Sur une inégalité lunaire à longue période. By M. C. Gogou.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associate during the past year:—

Fellows:—Richard Abbatt.
Thomas Barneby.
H. G. Bohn.
Rev. J. C. Ebden.
Rev. W. Falconer.
H. A. Fletcher.
William Frost.
H. R. Janisch.
H. C. Levander.
J. L. Shuter.
Rev. F. Silver.
Isaac Todhunter.
Thomas Turner.
F. D. Wackerbarth.
Thomas Watson.

Associate:—Marian Kowalski.

Richard Abbatt, whose death took place on September 15, 1884, was one of the oldest Fellows of the Royal Astronomical Society, having been elected in 1833, February 8. He was born at Jivecelton, in Lancashire, in the year 1800. His father, Edward Abbatt, dying in 1802, his mother removed with her little son to Whitehaven, and from thence to Torpenhow to reside near her parents. About the age of twelve he was placed at a large boarding school in Yorkshire, and some years afterwards apprenticed to a grocer in Carlisle. Here, in consequence of an accident, his health gave way, and, at the earnest entreaties of his mother, his master cancelled his indentures. On his recovery he was placed at Mr. Saul's school at Greenrow, under whose tuition he made considerable progress in mathematics, a science which continued to possess great charms for him through a long life. He was employed as mathematical master in a school in Hammersmith, and this he resigned to accept the same post in a school about to be opened at Tottenham for the sons of the upper class of the Society of Friends, of which religious body his family had long been members. His first work, on the "Elements of Trigonometry," was published in 1834, his next was on the "Calculus of Variations" in 1836, when residing at Epping, where he had removed to commence a school in partnership with

Dr. Usmer, his friend and fellow assistant at the last two schools. He removed his school to Stoke Newington in 1839. Here he published "The Picts or Romano-British Wall," "The Principles and Practice of Linear Perspective;" "The Ascent of Scawfell Pike;" "The Two Estates, or Both Worlds Mathematically Considered;" "Physical Astronomy;" "Taught from Above," and others. His latest work was a pamphlet on Life Assurance, published in 1883. He also published two Orthographic Projections of the World representing the Earth floating in space. In the year 1870 he was chosen one of the party sent out to observe the eclipse of the Sun at Gibraltar; the account of this expedition was published in the *Carlisle Journal* and other papers. On retiring from school business, he was presented with a gold chronometer, a beautifully illuminated album containing portraits of his early friends and pupils, and 1,000 guineas, as a mark of their respect and esteem. The last years of his life were spent at a delightful spot in Burgess Hill, built for him by one of his old pupils. His bodily powers had been gradually failing for two or three years, yet his health and strength were far beyond what is generally expected in a man of his age. He died, after a short illness, at the age of eighty-four, and his remains were interred in Park Street, Stoke Newington, the resting-place of a large number of his early friends. In life he was a most amiable and unselfish man, endeared to a large circle of friends by the refinement of his mind, his patient spirit, and his strict conscientious character. He was a most entertaining companion, possessing a wonderful memory of almost every book he had read, and the kind sympathy that accompanied all his actions won the respect and affection of all who knew him. Mr. Abbatt's favourite studies were mathematics and astronomy, and the pleasant and successful manner he possessed of imparting his own love for these subjects is remembered by many of his early pupils who still survive him.

Henry George Bohn was born in London on January 4, 1796. He claimed to be descended from a family of the name of Bohun, who being among the Protestant refugees who passed to the Continent in the reign of Mary, became possessed of estates at Weinheim, on the Rhine. His father, John Henry Martin Bohn, who had served his apprenticeship in Germany, settled in London, and carried on the business of a bookbinder and second-hand bookseller, in which he was assisted by his son.

Mr. Bohn had an early ambition to be a publisher; but not until 1846 did he commence the issue of the reprints and translations which constitute the Standard and other Libraries, and for which his name became so celebrated. It is to the enterprise of Mr. Bohn that we owe the introduction of so much good literature at a low price. His various "Libraries," The Standard, The Scientific, The Illustrated, The Classical, The Antiquarian,

&c., amounted to more than six hundred volumes, and the success which has attended their sale is an indication of the excellence of the publications.

He was a man of great energy, immense power of work, and great shrewdness. Constable had shown that books of a light and popular character would, if sold at a low price, meet with an extensive sale. Mr. Bohn proved that works of a solid cast, such as had been hitherto attainable only at high prices, would excite a remunerative demand if brought out at low rates. He certainly was one of the chief pioneers of cheap literature.

Mr. Bohn, who, for many years, had lived in York Street, Covent Garden, eventually resided entirely at Twickenham, where he devoted himself to gardening, and buying china and pictures.

Mr. Bohn married, in 1831, a daughter of the late Mr. Simpkin, who, with her two sons and daughter, survive him.

He was elected a Fellow of the Society on January 11, 1861.

JOHN HENRY DALLMEYER. In the annual report last year the Council were only able briefly to announce their regret at the news of the decease of this gentleman, who was for many years a member of this Society. They desire to add some further tribute to one who rendered, by his optical skill, such important service to Astronomy.

Mr. Dallmeyer commenced his career in this country in the employ of the late Mr. Andrew Ross (afterwards his father-in-law), under whose encouragement and tuition he cultivated and manifested his capabilities in both the mechanical and optical departments of his calling. His name was first brought to public notice in Sir John Herschel's article on "The Telescope" (in the *Encyclopædia Britannica*, 8th edition), in which a list of the most important refractors then known is given, and, as to several, it is noted that Mr. Dallmeyer laid claim "to the personal execution and the computation of their curvatures."

At the death of Mr. A. Ross in 1859, Mr. Dallmeyer started business for himself, confining his attention at first almost entirely to the astronomical telescope; he constructed several very fine object glasses, some of which were employed in the recent eclipse and transit of *Venus* expeditions. He did not construct many large instruments, the largest being of 8-in. aperture; but his process of polishing (a long and difficult one, conducted under water) enabled him to produce a "black" polish on the surfaces rarely met with.

At the International Exhibition of 1862 Mr. Dallmeyer showed that he had turned his attention to the construction and improvement of the photographic lens, and it is in "photographic optics" that he chiefly proved himself a thorough master of his subject, and rendered such important services to photography in all its branches.

His improvements in lenses for all kinds of work, and for

which he took out many patents, followed rapidly one after another. He was rewarded by the first honours as an exhibitor, and received from foreign Governments decorations in recognition of his services. The topographical departments of our own and other Governments left the optical work entirely in Mr. Dallmeyer's hands.

It is chiefly upon photographic optics that he contributed papers to periodicals, and his practical pamphlet "On the Choice and Use of Photographic Lenses" is well known. In the furtherance of celestial photography Mr. Dallmeyer aided largely in the construction of the photo-heliograph. The first that he supplied was to the Russian Government in 1863 for the Wilna Observatory, for taking 4-in. pictures of the Sun. This proved a great success, and the Harvard College Observatory was supplied with one the following year.

In 1873 five photo-heliographs of 4-in. aperture and 5-ft. focal length with secondary magnifiers, giving 4-in. Sun pictures, were supplied to the Government. These were all mounted on universal equatorial stands, and went to various destinations for the transit of *Venus* expeditions in 1874. They have been since employed in solar photography, and some have lately been fitted with new magnifiers giving 8-in. pictures.

Mr. Dallmeyer's work in the construction of microscope object-glasses is well known and appreciated.

His last effort was in the "Optical Lantern," which he endeavoured to make a scientific and perfect instrument at the request of his old friend the Rev. F. Hardwich, who was also the first to test and to report on the first photographic lens that Mr. Dallmeyer constructed. The importance of the Optical Lantern has asserted itself, and Mr. Dallmeyer's work did what was necessary in giving the true rendering in colour and line.

For some three years previous to his decease he suffered from ill-health, due to overwork, and was obliged to make several voyages and journeys for restoration. During the last voyage which he undertook, he expired on December 30, 1883, in his fifty-second year, while between Tasmania and New Zealand. His affectionate and modest disposition made him endeared to all that knew him, and his indomitable energy prevented him from sooner relaxing his hand from his work, which he truly loved, or we might still have had him among us.

He was elected a Fellow of this Society on June 14, 1861.

James Collett Ebden was born at Loddon, Norfolk, on the 14th of August, 1794, and died at the vicarage, Great Stukeley, Hunts, on February 15, 1884, in the 90th year of his age, being at that date the Senior Fellow of the Society. He was the son of Mr. John Ebden of Haughley, Suffolk, by his second wife Elizabeth, daughter of Anthony Collett, Esq., of Eyke, and granddaughter of Robert May, Esq., of Sutton, who was High Sheriff of Suffolk in 1758. The Suffolk family of Collett had

been settled in the county from the fifteenth century, and was a branch of the Colletts or Colets of Wendover, of whom was Sir Henry Colet, twice Lord Mayor of London, and father of the celebrated Dean of St. Paul's. Mr. Ebden received his school education at Stowmarket, whence he proceeded in 1813 to Caius College, Cambridge. He graduated in 1816 as sixth wrangler, having amongst his competitors Dr. Whewell, the late Master of Trinity College, second wrangler, Professor Cape, fifth wrangler, and Richard Sheepshanks, sometime Vice-President of the Society, tenth wrangler. He was elected in 1816–17 a Fellow of Caius College, and in 1817–18 Fellow and Tutor of Trinity Hall, which post he held for ten years, numbering amongst his pupils Lord Chief Justice Cockburn, the late Lord Lytton, and other distinguished members of the college and university. In 1821–22 he was appointed Vice-Master of Trinity Hall. He married in 1828 Eliza, daughter of Sydenham Feast Wylde, Esq., of the 7th Hussars, and granddaughter of Penyston Portlock Powney, Esq., M.P. for Windsor. Mr. Ebden was one of the original members of the Athenæum Club and of the British Association for the Advancement of Science, the annual meetings of which society he attended without intermission till he was past eighty years of age. He was distinguished as a classical and English scholar, and was well versed in the languages and literatures of several foreign countries. He was associated with Messrs. Riddle and Arnold in their lexicographical undertakings, and he is believed to have been engaged in earlier life upon other literary and scientific work, although he has not left any record by which it can be ascertained and verified. He was nevertheless possessed of accurate and very varied scientific knowledge, and took a warm interest in the objects and proceedings of the British Association until he was confined to his home by increasing age and infirmity.

Mr. Ebden was elected a Fellow of the Society on June 9, 1820.

WILLIAM FROST was born on August 19, 1805, at Thorpe-le-Soken, Essex. He married a daughter of Mr. W. J. Frodsham, and from 1832 to 1865 resided at Hackney, subsequently removing to Tulse Hill. He was the author of several works; among others an "Arithmetic," and "Arithmetical Tables," "Uranian Guide," "View of the Earth and Heavens," and "A Celestial Atlas."

He was a man of considerable energy and perseverance, making friends wherever he went, and was highly respected in every relation of life.

He was for many years a member of the British Association. He died on March 10, 1884, at Tulse Hill, where a memorial has been since erected in Trinity Church, "by those who, having known and valued him, desire to perpetuate his memory in the Church he loved and served so well." He was elected a Fellow of the Society on April 13, 1838.

HENRY CHARLES LEVANDER, M.A., a native of Norwich, received his education at the Exeter Grammar School and at Pembroke College, Oxford. He soon distinguished himself by his extensive reading in ancient and modern languages, both eastern and western, and in mathematics, in which he graduated with honours. His power to acquire knowledge was very great, and, gifted with great determination and a very retentive memory, there was hardly any branch of science in which he was not proficient. He was some years ago appointed one of the masters of University College School. He took a special interest in astronomy, but although possessing an Equatorial, his numerous avocations did not allow him much time for making observations. He was elected a Fellow of this Society on April 12, 1872; he was also a Fellow or member of several other learned societies.

JAMES L. SHUTER was born June 21, 1819. From his early youth to his last day he took the greatest interest in all that appertained to science, being specially attached to mechanics; and he owed his position and success in life entirely to his own unaided efforts and to his untiring thirst after knowledge.

He constructed two telescopes, the larger one being of about 4 inches aperture; and he originated a considerable improvement in the geometric chuck, which is described in the *English Mechanic*, for May 30, 1884. His wife died February 16, 1883. Two daughters survive him. His only son, Mr. James Shuter, F.R.C.S., Assistant-Surgeon to St. Bartholomew's and the Royal Free Hospitals, died November 1, 1883.

Mr. Shuter was a Fellow of the Chemical Society and the Society of Arts, and a member of the Amateur Mechanical Society. He was formerly a Fellow of the Geological and Meteorological Societies.

He was elected a Fellow of this Society February 13, 1863.

FREDERICK SILVER was born at St. John's Wood, London, in 1821. He received a private education in the early part of his life, afterwards proceeding to Worcester College, Oxford, where he graduated about the year 1846.

Soon after leaving Oxford he took holy orders, and eventually held the living of Norton, Market Drayton, where he was rector for more than thirty years.

Though laying claim to no high intellectual power, he was possessed of a kind and benevolent spirit, which he exercised for the benefit of those within his circle, and especially the humbler classes. At frequent intervals he gathered in his rectory grounds large numbers of the working classes from the neighbourhood for the purpose of lectures upon botanical, geological, and kindred subjects, and also to inspect the objects in his museum, the collection of which had occupied his attention for many

years. He thus endeavoured to elevate the masses and foster an interest in things superior to their everyday surroundings. He died at Norton, Market Drayton, on August 28, 1884.

His only child, a son, graduated at Christ Church, Oxford, but died shortly after taking holy orders.

Mr. Silver was for many years a Fellow of the Linnæan, Royal Geographical, Geological, and Meteorological Societies.

He was elected a Fellow of this Society on May 11, 1855.

Isaac Todhunter was born in 1820, and was the second son of a Congregationalist minister at Rye. Passing over his boyhood we find him an assistant-master in a school at Peckham, and at the same time attending the evening classes at University College, and among others the lectures of De Morgan. Here he seems to have come under the fascination which so many of the pupils of that great teacher experienced. His admiration for that mathematician was unbounded. He obtained great distinction in the University of London, carrying off the honours at the degrees of B.A. and M.A. He afterwards entered the University of Cambridge, and became Senior Wrangler and first Smith's Prizeman in 1848.

In the same year in which he took his degree he gained the Burney Prize. According to the regulations this prize is to be awarded for an English essay, to a graduate of the University who is not of more than three years' standing from admission to his first degree. His essay was printed in 1849 under the title "The doctrine of a Divine Providence is inseparable from the belief in the existence of an absolutely perfect Creator."

Soon after taking his degree he established himself at St John's College as a mathematical tutor and lecturer, but afterwards he gave up all share in the tuition of his college and devoted himself more and more to the work of writing books.

The great work of Dr. Todhunter's life lies in the part he has taken in the education of this generation. A detailed account of the numerous educational books he has written would be too long for so slight a sketch of his life as the present. His books conduct the student from the beginning through a long course of mathematical learning. A simple list of these is a history of the labours of his life; as the dates run on we see his time filled up with correcting one edition after another.

In constructing his books, he seems to have discovered that, for the teaching of boys, novelties would be out of place. What was wanted in any subject was a short and accurate account of the things then known. The object was to put the reader as quickly as possible in possession of all the knowledge which was most likely to be useful to him afterwards. Accordingly he gives in his books a clear statement of the well-known principles of each subject, arranged in a logical order. Each step in the argument is explained at length in clear English. Nothing is assumed but what a reader should know. Every page makes it

evident how thoroughly he was keeping in mind that he was writing for beginners.

Whatever his own ideas were, his books were certainly a great success. His "Euclid" and his "Elementary Algebra" have in twenty years run through fifteen or sixteen editions. They were appreciated by the schoolmasters, and by those who had to teach these subjects. With their recommendations, the sale has grown into something enormous. His more advanced text-books, being addressed to a more limited circle of readers, could not be expected to run through so many editions; yet we find his "Differential Calculus" reaching its ninth and his "Integral Calculus" a seventh edition.

His reputation in future time will undoubtedly rest on his histories, for the fashion of elementary books will pass away, and a new generation will like a new arrangement of old things. The most important of these are (1) "A history of the progress of the Calculus of Variations during the nineteenth century:" 1861; (2) "A history of the Mathematical Theory of Probability from the time of Pascal to that of Laplace:" 1865; (3) "A history of the Mathematical Theories of Attraction and the Figure of the Earth from the time of Newton to that of Laplace:" 1873. The first of these is a continuation of Woodhouse's history of the Calculus of Variations from its origin until the close of the eighteenth century; and it has been stated that it was his admiration for this work that led him to write this history.

These books appear to the writer of this notice to be of great importance. It is a great boon to the student to have a short and clear account of what has been already done, and what remains to be accomplished in any subject. Though the third of these histories extends over two volumes of nearly five hundred pages each, yet these are not too much for so great a subject.

It is unnecessary to give a particular account of these histories, as they have now been some time before the public. But we would call the attention of those who have not yet read them to their extreme interest. As we read one of them it seems as if a new light were thrown on the subject. The difficulties of each investigator are put before us; we see how the subject advances, each discoverer adding a little, until step by step we arrive at our present state of knowledge. We see here sketched out before us the gradual growth of those modern methods which we now find so ready to our hands. Thus, in one place, Dr. Todhunter points out the first appearance of those confocal shells which play so important a part in modern works of attraction. These appear in a memoir of Maclaurin's, who introduces them in a remarkable manner without appearing to realise their importance. In another place, we find a sketch in eight pages of a memoir of Legendre's which Dr. Todhunter considers to be the foundation of all that Laplace added in the theories of attraction and the figure of the Earth to the works

of Maclaurin and Clairaut. As we read the sketch, we see the first beginning of Laplace's coefficients and a recognition of the importance of the potential. This was the commencement of a new era in mathematical physics. In a third place, the history shows us how D'Alembert, trying to find the attraction of an ellipsoid, makes it depend on a single definite integral. This result, Dr. Todhunter reminds us, is the point at which modern investigations have finally arrived. But D'Alembert, after effecting this, strangely rejects his result as inadmissible. "In his process," says Dr. Todhunter, "there is nothing wrong in principle, but he has omitted a bracket which renders his result slightly inaccurate. He gives some invalid argument against his method. Thus D'Alembert deliberately rejects one of the most important formulæ of the subject, which in fact quite supersedes a large part of his memoir. This is perhaps the strangest of all his strange mistakes." A little further on in the history, we read how Laplace values and appropriates the treasure which D'Alembert deliberately threw away.

Dr. Todhunter has contributed a few papers to the societies to which he belonged. These are chiefly historical, and seem to have risen out of the histories on which he spent so much of his time. Some are occupied with discussions on the errors into which former writers have fallen, while others contain extensions of theorems already established. To the Royal Astronomical Society he contributed two short papers, which have both appeared in the *Monthly Notices*. In the first of these he mentions what seems to be a curious contradiction between the reasoning given in props. 36 and 37 of the third book of Newton's "Principia" and the statement made in prop. 38 of the same book. In the first two Newton discusses the forces of the Sun and Moon to move the sea, and in the last he applies the same general reasoning to find the figure of the Moon as disturbed by the attraction of the Earth. Yet while the first are quite correct, the last is wrong. The interest of the paper lies in the fact that, though this mistake was pointed out, with some emphasis, as long ago as a little past the middle of the last century, yet it does not seem to have been generally noticed by commentators on the "Principia." The second paper contributed to the Royal Astronomical Society is devoted to geodesy. An arc of the meridian measured in 1752 by La Caille, an astronomer whose accuracy has a great reputation, was found to be decidedly longer than might have been expected from measurements made in the northern hemisphere. The arc has in recent times been again measured by Sir T. Maclear, whose result is more in harmony with the northern arcs. But though the excellence of Maclear's work is beyond question, yet various difficulties and contradictions remain. These are shortly summed up by Dr. Todhunter with the hope of obtaining some explanations from those engaged in the measurements. In connection with this subject we may here allude to a longer paper contributed by Dr. Todhunter to the

twelfth volume of the *Cambridge Transactions* (1871). This is practically a history of the measurement of the famous Lapland arc first by the French and afterwards by the Swedish astronomers. He says that though the accounts of these measurements are easily accessible and written by distinguished astronomers, they yet contain numerous and serious errors. The arc then measured is a small one (being less than one degree), and therefore now unimportant when compared with the large arcs which have been since measured. The interest is, therefore, chiefly historical. It was maintained by Cassini in opposition to Newton, that the polar diameter of the earth was longer than the equatorial diameter. The operations carried on in Lapland by Maupertuis showed that the length of a degree of the meridian at the arctic circle was 57,437 toises. This was about 1,000 toises larger than it should have been according to the Cassinian theory. The result astonished the French observers. It is said that they kept this very secret, in order to reflect at leisure on what had been so little expected, and to have the pleasure of bringing the first intelligence of it to Paris.

Dr. Todhunter has also written four papers connected with the theory of the Figure of the Earth. Three of these are published in the *Proceedings* of the Royal Society. The first of these (vol. xix.) is on Jacobi's theorem on the ellipsoid of relative equilibrium and on Ivory's discussion of the theorem. In the second (vol. xx.) he gives an extension of the theorem of Poisson on the attraction of spheroids. In the third (vol. xxi.) he corrects a mistake of Dahlander. In a fourth paper, in the twelfth volume of the *Cambridge Transactions* he begins with the fundamental equation to find Yn in the Figure of the Earth; he then examines the various proofs that the only admissible value of Yn is zero given by Legendre, Laplace, O'Brien, &c., and points out the objections to each. He then concludes with a proof of his own.

We have occupied so much space with remarks on those papers of Dr. Todhunter which are more nearly connected with astronomy, that we have no room for more than an allusion to his other writings. There is a paper in the eleventh volume of the *Cambridge Transactions* on the mothod of Least Squares, which was evidently suggested by his history of the Mathematical Theory of Probability. In two papers in the *Proceedings* of the Royal Society for 1875 and 1878 he discusses the value of the integral of a product, first, of two, and next, of three of Legendre's functions.

In 1869, the subject prescribed for the Adams' Prize was "A determination of the circumstances under which Discontinuity of any kind presents itself in the solution of a problem of Maximum or Minimum in the Calculus of Variations." The proposal of this subject seems to have arisen from a controversy which had been carried on in the *Philosophical Magazine* a few years previously. In this controversy Dr. Todhunter had taken part, and

when the subject was proposed for the essay he was anxious that his own view should prevail. This view is given in the opening sentences of his essay:—"We shall find that, speaking generally, discontinuity is introduced by virtue of some restriction which we impose, either explicitly or implicitly, in the statement of the problems which we propose to solve." This thesis he supports by considering in turn the usual applications of the calculus, and pointing out where he considers the discontinuities which occur to have been introduced into the conditions of the problem. This he successfully proves in many instances. In some cases, the want of a distinct test of what discontinuity is, somewhat obscures the argument. His essay was rewarded with the prize. It is published under the title "Researches in the Calculus of Variations."

In the midst of so busy a life, Dr. Todhunter could yet find time to write for others. The second edition of Boole's "Differential Equations" was published under his care; and, what is more, he undertook the labour of arranging and editing the supplementary volume. This task was undertaken from friendship to the late Professor Boole. The difficulty of preparing unfinished papers for the press is obvious; and it is not surprising that, as he once mentioned to the writer, it should have cost him some months of hard work.

Dr. Todhunter has left a treatise on Elasticity, which was very nearly finished. The time and labour he spent over this work injured his eyesight, and probably led to his final illness. These MSS. had been sent to Professor Cayley to report on; and we learn from Professor Mayor's pamphlet that the investigation shows that they are of the same class as the history of the Theory of Attraction, and seem fairly complete.

Another result of the labours of his latter years is a treatise on Arithmetic. Such a work when perfected would have smoothed the way for the young beginner over many difficulties. It is greatly to be regretted that he did not undertake it sooner.

In the summer of 1880 Dr. Todhunter first began to suffer from his eyesight, and from that date he gradually and slowly became weaker. But it was not until September 1883, when he was at Hunstanton, that the worst symptoms came on. He then partially lost by paralysis the use of the right arm, and, though he afterwards recovered from this, he was left much weaker. In January of the next year he had another attack, and on March 1, 1884, he died at his own residence in Cambridge, surrounded by his dearest relatives. It was a fit ending to an honourable and respected life spent in the advancement of that science which he loved so well.

He was a member of many learned societies. He became a Fellow of the Royal Society in 1862, and served on the Council during the years 1871–1873. He was elected a member of the Mathematical Society of London in 1865, the first year of its

existence. He was elected a Fellow of this Society on January 11, 1850, and was a member of the Council during the two years from February 1868 to February 1870. Lastly, when the University of Cambridge established its new degree of Doctor of Science, restricted to those who have made original contributions to the advancement of science or learning, he was one of those whose application was granted within the first few months.

E. J. R.

THOMAS TURNER was born at Hull, December 13, 1804, and was the third son of Ralph Turner, a merchant of that place. He was educated at Bingley School, in Yorkshire, under the Rev. Dr. Hartley, and subsequently under the tutelage of the Rev. C. Bird, late Canon of Lincoln.

In 1823, he entered at Trinity College, Cambridge, of which he became a scholar and afterwards Fellow, having been second Wrangler and first Smith's Prizeman in 1827.

After taking his degree, he for a time took pupils, amongst whom was the late Mr. Milner Gibson. He then took up the study of law, and was called to the bar as a member of the Society of Lincoln's Inn. He practised as a barrister in London till 1846, when he retired from practice and devoted himself to philanthropic works. Upon the consecration of his valued friend, the Rev. Charles Perry, to the bishopric of Melbourne, he took much interest in the affairs of that diocese, and by his legal knowledge was able to give valuable assistance in obtaining the assent of the Queen to the act of the Victorian Parliament for the constitution of a Church of England Legislature in the colony.

About the same time also he was able to give much help to the people of Manchester, through his connection with Mr. Henry Charlewood, in obtaining the "Parish of Manchester Division Act," 1850, whereby the parochial duties of the dean and canons, and the disposal of the revenues were regulated, and provision was made for the division of the ancient parish of Manchester into separate rectories. Great research was necessary, and the effect of various charters had to be considered. To this difficult subject Mr. Turner devoted his time and talents, and to the assistance he gave the comprehensiveness and value of that Act was largely due.

About 1848 he was made a magistrate for the county of Middlesex, and was for several years chairman of the Parliamentary Committee, besides being an active member of several other committees. He was subsequently made a deputy-lieutenant of the same county.

In 1855, on the passing of Sir B. Hall's Local Government Act, he was elected as a member of the Metropolitan Board of Works, for Hampstead, and later on, after his removal to Southwark, he became a member of the Board, for St. Olave's.

In 1856, Mr. Turner undertook the office of treasurer to

Guy's Hospital, and principally resided there during the twenty years he held it. He did much for the advancement of that institution, and of the Medical School connected with it, and his work was highly appreciated there.

Previous to his resignation of the treasurership of Guy's Hospital in 1876, Mr. Turner's health had already begun to fail, and it continued to do so, very gradually, until on April 9, 1883, his energetic and useful life came to an end.

Mr. Turner was one of the earliest Fellows of the Royal Astronomical Society, and took much interest in that science. Though he made no important contribution to this or other branches of science, he had many friends among those engaged in them. Among the most distinguished of whom was Sir George Airy, late Astronomer Royal, who had been his college tutor.

Amongst other subjects, Mr. Turner devoted much time to the study of Hebrew, and published a Metrical Version of the Book of Psalms, from the original text.

In 1835 he married Mary Anne, daughter of the Rev. Charles Benjamin Charlewood, of Oak Hill, near Cheadle, in Staffordshire, the issue of the marriage being three sons and four daughters, four of whom are still living.

Mr. Turner was elected a Fellow of the Society on May 11, 1832.

Francis Diedrich Wackerbarth was born in London on January 30, 1813. He was descended from an old German family whose patrimonial estate was the baronial manor of Rogel in the ancient Duchy of Lauenburg. A descendant of this family, George Wackerbarth, came in the year 1752 to London, and there founded a sugar refinery, which afterwards descended to his son John Henry Wackerbarth, who died 1818. His son Francis Diedrich, one of a family of ten, was considered by those around him as most suitable for the clerical profession, and accordingly he received an education intended to qualify him for it. In the year 1831 he left the Rev. Dr. Laing's school in Clapham for Cambridge, well grounded in classics and mathematics. He took his degree as B.A. in 1835, and left Cambridge in 1837, having been appointed to the curacy of Peldon, in Essex. A few years later he became a minor canon of Lichfield Cathedral, but as early as 1841 he entirely abandoned the clerical profession and joined the Roman Catholic Church, receiving in his baptism the name of Athanasius.

During this short period of his life, viz., from 1837–41, he developed a remarkable literary activity, which was connected with the gradual approximation of his views to those of the Roman Catholic Church. Works written by him during this period are: "Music and the Anglo-Saxons; being some account of the Anglo-Saxon Orchestra, with remarks on the Church Music of the Nineteenth Century," London, 1837; "The Alleged Connexion between the Church of England and Luther-

anism," London, 1839; "The Revival of Monastic Institutions and their Bearing upon Society," Colchester, 1839; "Tuba Concordiæ, or a Letter to the future Prime Minister relative to the Pacification of Ireland and the Condition of the Church," Lichfield, 1841; "The Egyptian Bondage, or a Second Call to Union," London, 1842. It lies beyond the province of this biography to touch, if ever so briefly, on the contents of these works, but we may remark, in passing, that they are characteristic of a prominent feature in Mr. Wackerbarth's disposition, viz., always to express boldly his conviction, and to act without hesitation upon it—nay, even to suffer for the opinions he embraced. It is significant of Mr. Wackerbarth's activity that whilst he was curate of Peldon he appears to have rendered some important assistance in making the necessary calculations for the construction of a railway.

After his secession to the Romish Church he lived chiefly in private life, devoting himself to studies, among which languages took the most prominent place. He thus spent somewhat above ten years in England, for the greater part of which time he resided in Hammersmith. He was Professor of Anglo-Saxon at St. Mary's College, Oscott, and in the year 1849 published his "Beowulf," an epic poem translated into English verse, and printed in London the same year. A critique of this work is to be found in *The Weekly and Monthly Orthodox*, 1849. The same year he became a member of "Kong. Nordisk Oldskriftselskap i Köpenhavn."

In the year 1851 Mr. Wackerbarth undertook a journey to Copenhagen for the study of languages. He paid a visit to Upsala at the same time and found the state of things there so congenial to his tastes that he returned in April of the following year to remain there for life. In 1853 he became naturalised as a Swedish subject. On his first visit to Upsala he had made acquaintance with the director of the Astronomical Observatory, Professor G. Swanberg, and in this way was soon intimately connected with this institution. Astronomy always formed one of his favourite studies. He presented to the Observatory his refractor, a good instrument, though small, and he diligently shared in the astronomical work. Extremely unpretentious as regarded himself, he willingly accepted, in 1860, the office of *Amanuensis* to the Observatory, the only official post which could be offered to him, and which he managed during eighteen years with the greatest accuracy. Among the purely astronomical works which he published during this period are "Om Planeten Neptunus," printed in the Report of the University of Upsala for 1865, and a provisional theory of "Leda," Nov. acta R. Soc. Sc. Upsaladensis 1866. He is besides known in the astronomical world through his papers in the *Monthly Notices*. Other scientific works which he published during his sojourn in Sweden are "5-ställiga Logarithmer," with tables for numerical calculations, a book which is both well arranged and much used in

Sweden; "On the Great Pyramid of Gizeh," originally written for a Swedish periodical, but translated into English, and printed in London, 1871, in which he disputes the opinion that the dimensions of the above-mentioned pyramid contain intentional expressions for certain astronomical constants; "Hymn of St. Ephrem Syrus," London, 1852, a metrical translation from Syriac to English, and the little pamphlet "Om de gamla Egyptiska läroverken," Upsala, 1871, in which, on the strength of Mr. Chaba's book, "Voyage d'un Egyptien en Syrie, etc.," he makes some remarks respecting the University of Egypt in the time of Ramases the Great, are also monuments of his studies in Eastern literature. But much intelligent work has been executed by Mr. Wackerbarth which has not been published by himself. Wherever he could assist by his knowledge and his perseverance it was a real pleasure to him to do so. One might be sure that the work would be done quickly and well. Thus he has among other things contributed to the Syriac Lexicon, "Thesaurus Syriacus," published by the Rev. R. Payne-Smith, of Oxford, who honourably mentions his name in the second number of this great work.

The above gives but an imperfect idea of the extent of learning Mr. Wackerbarth possessed. He had the most thorough knowledge of the old classical authors. Next in order came the Semitic languages, Anglo-Saxon, and Icelandic. He was also a member of the Literary Society of Iceland; and besides the usual modern languages, he was well versed in Italian, Swedish, and Danish. He expressed himself with elegance and ease in verse, and in the *Dublin Review Advertiser* he published remarkably able translations of Tegnér, Runeberg, and Wallin. In history he had a vast knowledge, and quite uncommon insights in Church history. He was also a skilful sketcher of architectural objects, and well learned in the theory of musical composition, although few researches on these subjects were printed.

To complete the features of his life we must mention that he became a member of the Royal Society of Science in Upsala in 1858, and in 1866 he was there promoted to be honorary doctor by the Faculty of Philosophy. The same year he was presented with the Order of the "Northern Star." In 1859 he married the daughter of a Swedish rural dean, the Rev. C. O. Ekman, who alone survives him. In the year 1875 he was struck down by a fit, which considerably enfeebled his strong constitution, yet he continued to devote his remaining strength to scientific pursuits till a further attack of illness suddenly terminated his life on June 10, 1884.

Mr. Wackerbarth was, as one can readily see from the above sketch, a man gifted with an astonishing memory, an uncommon power for work, and an especial ability to grasp at once the most important parts of a subject. And without doubt it was a loss to science that the earlier stage of his life was devoted to other pursuits. In his views, as in his studies, he endeavoured

always to place himself as far as possible on the foundation of objective truth, and never spared any labour to attain this object.

For scientific metaphysics he entertained disgust, but still more for the want of clearness and consistency, and often even want of truth by which human work during the development of the great questions of the day is usually impaired. Perhaps this was partly the reason why he gladly sought subjects for his studies as well as foundations for his views far back in the history of the world, a tendency to which finds its expression in the motto (of Rabelais) with which he introduces his first work, "Music and the Anglo-Saxons," "*En quoy coignessez-vous la folie antique? En quoy coignessez-vous la sagesse moderne?*" A stranger to all kinds of dissimulation, he often displayed his views in a striking contrast to the opinions of the present day; yet supported as they were by his prodigious knowledge, and exposed with a particular clearness, they could not fail to compel attention, whilst, at the same time, he usually softened the contrast by an equally brisk and good-natured humour. He was very religious, yet without a trace of bigotry, and to the last moment his heart showed a youthful warmth and sympathy for others. In this way he drew his contemporaries into close communion with himself in spite of differences in rank and views. He was, therefore, also the favourite of the academical youth of Upsala, who elected him honorary member of two of their so-called "Nations," or college societies; at the same time he was highly valued by the elder academical world for his learning and character. He was buried in Upsala churchyard. The inscription on the wreath which the Academy of Sciences in Upsala then laid upon the grave of this noble stranger strikingly portrays his character: "*Varietate disciplinæ et copia omnia cepit, simplicitate animi et liberalitate omnes.*"

He was elected a Fellow of this Society on January 12, 1849.

F. L. E.

Ernst Friedrich Wilhelm Klinkerfues was born at Hofgeismar, in Hesse Cassel, on March 29, 1827; he was the eldest son of the surgeon of a Hessian regiment of Hussars. At an early age he was entrusted to the care of two aunts, who sent him first to the burgher school, and in his fourteenth year to the Gymnasium, at Cassel, where he found a home in the house of his uncle, the late Obergerichtsrath Dedolph. As a boy he is said to have been shy and studious, taking but little part in the ordinary amusements of his schoolfellows, although his affectionate disposition led him all the more keenly to enjoy the vacations spent with his brothers and sisters at their home, which was now at Spangenberg, where his father was professionally employed at the military hospital. Owing to the partiality displayed by Klinkerfues for the natural sciences, he left the Gymnasium for the Polytechnic School while yet in the

secunda, carrying with him the most flattering credentials from Dr. Weber, then director of the Gymnasium. On the death of his uncle Dedolph, Klinkerfues took lodgings in the house of an optician named Fiorino, in Cassel, and thus fell in with some old astronomical instruments, one of them being a reflecting telescope. He at once conceived a most ardent desire to learn the use of these instruments, a desire the more easily gratified in part, as his room in the "Colonnades" had a kind of balcony affording a free prospect of the heavens. At this time he began to study, with the greatest zeal, various astronomical books procured from the public library in Cassel, the Hessian "Landesbibliothek." Thanks to his training at the Gymnasium, he was able to read Lalande's "Astronomie," and later on Gauss' "Theoria Motus," in the original languages. After distinguishing himself at the Polytechnic School for industry and good behaviour, Klinkerfues passed his examination as surveyor (*Geometer*) in 1844, and eventually in 1846 was employed in the construction of the Main-Weser railway, but this did not prevent him from still drawing largely on the Cassel library for a supply of his favourite literature. Employed in the construction of the above-named railway, through the kindly interest of the director of the works (Obergerichtsrath Weiffenbach), Klinkerfues was stationed at Marburg, with special permission to attend the University lectures.

In this way Klinkerfues retained his post on the railway, and heard the lectures of the late Professor Gerling, besides taking part in the practical work at the Observatory; and, in common with a large class of zealous students, amongst whom were Professors Tyndall and Schönfeld, in the registration of the deflections of the magnetic needle. Klinkerfues' earliest observations of an eclipse of the Moon, some occultations, and also of *Ceres* and *Neptune*, are published in the 30th volume of the *Astronomische Nachrichten*.

Late in the spring of 1851, Klinkerfues resigned his post, and went to Göttingen with the warmest recommendations of Gerling, and with the somewhat reticent approval of Gauss, as we have just learnt through the publication, in No. 2573 of the journal just mentioned, of a most interesting letter from the great mathematician to Gerling, dated May 10, 1851. It is pleasant, however, to find that the same letter expresses the generous apprehension that undue caution on the writer's part may possibly have shaken Klinkerfues' intention of coming to Göttingen. In that University, however, Klinkerfues took up his residence in the summer session of 1851, and so far satisfied Gauss of his capabilities, that he was installed assistant at the Observatory at Michaelmas in the same year, having already taken part with Gauss and J. G. Westphal in the observation of the eclipse of the Sun on July 28. That autumn he computed two sets of elements of Eunomia, the first along with Westphal, who held the post of "Observator;" these were followed by elements of Comet IV., 1851. Shortly afterwards Klinkerfues

computed the difficult orbit of *Psyche*, preparing the way for the rediscovery of that planet in 1853. It is well known that Gauss was much gratified with the application of a special method given in the "Theoria Motus."

In June, 1853, Klinkerfues became more widely known through the discovery of Comet III. of that year, which afterwards became so bright as to be observed in the daytime at Olmütz and at Liverpool. This was the first of Klinkerfues' discoveries in this field, to which he afterwards added five other Comets—1854 III., 1854 IV., 1857 III., 1857 V., and 1863 II., besides independently finding Comets 1854 I., and 1855 II., the latter only one day after its discovery by Donati. To return to the year 1853—to all outward appearance nothing could be more promising than the career of the young astronomer, actively engaged in advanced theoretical studies, favourably known as a discoverer, and possessed of a phenomenal facility in the performance of elaborate calculations; and yet, even at this early stage, there is reason to fear that his private affairs were so seriously involved as materially to prejudice his further satisfactory advancement.

Gauss died on February 23, 1855, and the Göttingen Observatory was placed under the nominal direction of the well-known Professor W. Weber, with Klinkerfues as "Observator," in the place of Westphal, resigned. In this year Klinkerfues took his degree of Doctor of Philosophy, his inaugural dissertation being the essay, "Ueber eine neue Methode die Bahnen der Doppelsterne zu berechnen." In this year, also, he was made Assessor of the Royal Society of Sciences of Göttingen, but, unfortunately, was not destined to become a full member of that body. Amongst other labours about this time, an extensive series of zone-observations were commenced, in conjunction with Dr., afterwards Professor Schering, and various successive associates. The method of recording the declinations in these zones much resembled that introduced, with such signal results, by Gauss for following the variations of the magnetic needle. A mirror was fixed to the Transit-Circle, and in it were observed the reflected divisions of a fixed ivory scale, as seen through a large Transit instrument, mounted in the same meridian as the Transit-Circle a few paces to the north. Much labour was bestowed upon these observations, and about 6,000 mean places for 1860·0 were deduced; but owing, it is believed, to the discovery of certain systematic errors, they have not yet been published. There are besides, according to Professor Schering, about as many unreduced observations, and one cannot but join in the wish that these may eventually be utilised (see *Ast. Nach.*, No. 2573).

Klinkerfues was nominated Provisional Director of Göttingen Observatory in 1859, Extraordinary Professor of Astronomy in 1863, and eventually director of the Observatory for Practical Astronomy in 1868.

During these years of tardy advancement, Klinkerfues never managed to shake off the load of debt that oppressed him, and only to his singularly elastic and genial temperament can it be ascribed that he was still able to abstract himself from his troubles, and labour zealously in the enchanted field of original investigation. About 1864 he became absorbed in optical studies, more particularly in that of the refrangibility of light, as affected by the motion of its source, and the medium through which it passes. In these difficult investigations, his own experiments with an achromatic prism in 1865 led to no satisfactory results, although they were not without their value in directing attention to the subject, afterwards so successfully dealt with by the dispersive prism in the hands of Dr. Huggins and others. In like manner his imperfect experiments on the possible dependence of the constant of aberration on the thickness of the object-glass of the telescope employed, served but to prepare the way to the complete settlement of the question in the negative by Sir George Airy. About this time Klinkerfues published translations (into German) of Briot's "Essai sur la théorie mathématique de la lumière," and of Dr. Huggins' Nottingham lecture on Spectrum Analysis, as applied to the heavenly bodies. The latter passed through more than one edition; and in a much modified and expanded form, as a supplement to recent editions of Mädler's "Wunderbau des Weltalls," forms one of the most lucid elementary treatises on the subject.

In 1881 he rescued from oblivion T. Mayer's original lunar sketches, made about the middle of last century, a small number of copies of which were phototyped under the title of "Tobias Mayer's grössere Mondkarte nebst Detailzeichnungen," Göttingen, 1881; one of them is in the Society's library.

In his character of professor, Klinkerfues usually read three courses of lectures—on spherical, on theoretical, and on perturbational astronomy. In each of these departments his teaching was distinguished by the great variety of his methods of exposition. In his hands the most hackneyed subject assumed some fresh interest, or was regarded from some new and unexpected point of view. This is clearly exemplified in his published work, "Theoretische Astronomie," which will long remain a favourite work amongst students of astronomy. In this work the relation between shooting-stars and comets is dwelt on at length in a special section, in which the term "radiant of convergence" is introduced; hence, on the appearance of the great display of shooting-stars on November 27, 1872, Klinkerfues quickly came to the conclusion that the departing swarm of meteors ought to be visible in the neighbourhood of θ *Centauri*. How his telegram to Madras led to the observation by Mr. Pogson, on two occasions, of a cometic body in the region of the heavens indicated, is a part of the history of astronomy, although it is not universally admitted that the object so seen was associated either with the meteoric display, or with Biela's comet. Should the coinci-

dence, after all, have been only accidental, it would, indeed, be an occasion for the application of Schiller's lines, already quoted by Sir John Herschel in another connection—

> Mit dem Genius steht die Natur in ewigem Bunde,
> Was der Eine verspricht leistet die Andre gewiss.

Later on Klinkerfues devoted much care and thought to the improvement of the hair hygrometer, and eventually produced a bifilar instrument, of which the theory is as elegant as it is interesting. This instrument, when tested at even wide intervals, is calculated to be of great use whenever it is desirable to know the relative humidity of the air at a glance. An attempt to utilise this instrument in the local prediction of weather, notably of rainfall, was not without a considerable measure of success, although from the very nature of the problem its applicability to large areas may well be doubted. Other inventions, ingenious enough in themselves, served only to lead him into business engagements which he was totally unfitted to deal with.

Professor Klinkerfues' contributions to the daily journals ranged over a great variety of subjects, but all his papers were singularly readable, and often contained the most original and suggestive ideas. Occasionally, indeed, they were altogether of a quaintly humorous character, introducing, for instance, the alleged wonderful discoveries of an imaginary Professor Monkhouse, who read the past history of our globe in the reflections from the surfaces of the fixed stars. The Royal Society's Catalogue enumerates fifty-two of his scientific papers in addition to nine published in conjunction with J. G. Westphal. More than thirty years ago he was nominated corresponding member of the Academy of Antwerp, and was subsequently decorated with the Order of the Guelph by the late King of Hanover, at whose instance he observed the total eclipse of the Sun on July 18, 1860, at Cullera, in Spain.

It would be useless and almost impossible to attempt to describe how the warm-hearted and genial astronomer failed to take that position amongst his colleagues to which his undoubtedly great natural talents entitled him. His extreme carelessness of late years in his outward appearance was certainly much against him, but the unflagging zeal with which he delivered a whole course of lectures, if need were, even to a single student, ought to have told in his favour, as to some extent it doubtless did. But on one ground or other the title of *Professor ordinarius* was withheld from him to the last, although eventually the equivalent stipend was conferred upon him. Still the pleasure the official recognition of his ability would have afforded him may be gathered from the evident and warmly expressed satisfaction with which he regarded his election as Associate of our Society. But nothing could dispel the gloom that settled over him with the complete wreck of all his financial

plans, to which was added the load of failing health, perhaps mental as well as bodily, until at last he found in death a release from that life so fraught with care and anxiety. This took place on January 28th, 1884.

He was elected an Associate of this Society on November 10, 1882.

R. C.

Marian Kowalski was born at Dobrzyn, in the province of Plozk, on August 15, 1821.

He was the son of a Polish nobleman, and received his early education at the Gymnasium of Plozk, removing subsequently to Warsaw, where he was trained for an engineer. The prospect of success was not encouraging, and he therefore, in 1841, entered himself as a student at the St. Petersburg University. Being ignorant of the Russian language, though proficient in German, French, and Latin, he had many difficulties to contend with; but by giving private lessons, he managed to keep himself and a younger brother at St. Petersburg.

In 1845 he left the university, after receiving the gold medal for his essay on "The Principles of Mechanics." The next year he passed his Master's examination, and took his degree upon an essay "On the Perturbations of Comets," which he wrote in Russian. This essay was unfortunately never printed.

For the greater part of the year 1846 Kowalski lived and worked at the Pulkowa Observatory.

In the spring of 1847, the Russian Geographical Society sent an expedition, under the command of Colonel Hofmann, to explore the little-known region north of the Ural Mountains. Young Kowalski, who had obtained a reputation among the savants of St. Petersburg for his astronomical and mathematical ability, was appointed astronomer to the expedition, for the purpose of determining the position and height of the Ural Mountains between Tscherdyn in the Government of Perm and the Arctic Sea, to serve as a basis for charting the neighbouring rivers Ob and Petschora. Great difficulties were met with—climatic and otherwise—which permanently affected his health.

The results of this expedition were published in the first volume of "Der Nördliche Ural und das Küstengebirge Pae-Choi, 1883." In this work we find the positions of 186 stations laid down for astronomical observations, and the heights of 72 points in the Northern Ural Mountains, determined partly from trigonometrical and partly from barometrical observations.

Kowalski was requested by the St. Petersburg Academy of Sciences to undertake some magnetic observations during this expedition; and he succeeded in determining the magnetic elements of five stations in the extreme north, where he happened to stay. He also made many meteorological observations.

From these magnetic observations he made a mathematical investigation on "The Opposite Working of Two Magnets and

the Determination of the Horizontal Intensity of Terrestrial Magnetism," which was published in Russian in 1852.

In August 1850 Kowalski was appointed Assistant Astronomer at the University of Kasan. At this time he had already commenced his researches on the planet *Neptune*, which soon after brought his name into notoriety. In 1852 he published at Kasan a dissertation in Russian, "On the Motion of *Neptune*," and for this work and that on the Ural Expedition he was awarded the Demidowschen prize of the St. Petersburg Academy of Sciences. In this first paper on the motion of *Neptune* Kowalski gave the elements of the orbit derived from a limited number of observations. In 1855 he undertook a new investigation of the orbit, availing himself of all observations published up to 1853. This work, entitled "Recherches sur les Mouvements de *Neptune* suivies des Tables de cette Planète," was published at Kasan in 1855.

It consists essentially of two parts. In the first part the author investigates the corrections to be applied to the elements of the planet, taking into account the perturbations produced by *Jupiter*, *Saturn*, and *Uranus*. The materials which form the basis of this discussion consist of the early observation of the planet by Lalande in 1795, and all the accessible modern observations extending from 1846 to the close of 1853. The corrections applicable to Walker's elements of the planet published in 1847, from observations extending over a very small arc, are small.

The following are the definitive values of the elements obtained by Kowalski:—

Epoch 1850. Jan. 1, Greenwich Mean Noon.

Mean Longitude...	$334^{\circ}\ 36'\ 29''.78$
Longitude of Perihelion ...	$50\ 16\ 39.08 + 51.014t$
Longitude of Ascending Node ...	$130\ 7\ 45.30 + 39.615t$
Inclination	$1\ 47\ 0.89 - 0.346t$
Mean Motion	7873.993
Mean Distance	30.03386
Eccentricity	$0.0091736 + 0.0000000558t$

Professor Newcomb has shown, from a comparison of Kowalski's ephemeris with heliocentric longitudes derived from observations extending over a longer period, and using his perturbations, that the above elements require some small corrections.

The second part of Kowalski's memoir contains Tables of the planet founded on the corrected elements. In Table I. the author gives the heliocentric longitude and latitude and the logarithm of the radius vector for every thirty days throughout

the period extending from 1846 to 1880, with columns of differences for interpolation.

Table II. contains the value of certain of the subsidiary quantities depending on the heliocentric rectangular co-ordinates of the planet, by means of which, in connection with the Sun's rectangular co-ordinates given in the *Nautical Almanac*, the geocentric right ascension, declination, and distance of the planet may be found for every thirty days from 1850·0 to 1880·0. Professor Newcomb has, however, called attention (*Monthly Notices*, vol. xxv. p. 45) to certain errors in these Tables which prevent them from accurately representing the motions of the planet.

In 1851 Kowalski went with Professor Popow to Berdjansk, on the Sea of Azov, to observe the total eclipse of the Sun on July 28, the results of which appear in the publications of the Kasan University for 1851. In this expedition they fixed the geographical position of ten of the principal towns on the Volga, the longitudes being determined by means of fourteen chronometers, and the latitudes with a transit instrument.

On the retirement of Professor Liapounov, in 1854, from the direction of Kasan Observatory, Kowalski was appointed his successor.

In 1856 he published a paper in Russian on eclipses, in which he gave his own methods for the complete calculation of eclipses and occultations.

In 1859 three important papers by Kowalski appeared in the "Recherches Astronomiques de l'Observatoire de Kasan." The first one, entitled "Sur les lois du mouvement propre des Etoiles du Catalogue de Bradley," was devoted to a discussion of the question whether the proper motions, and consequently the true motions, of Bradley's stars were subject to other laws than those governing the motion of the solar system in space, and what deductions could thence be made with regard to the structure of the stellar system, and the forces which rule it. The discussion is based entirely upon Mädler's proper motions of Bradley's stars. The result arrived at is that there exists a zone of minimum proper motion, which crosses the equator at 111° 43′ and 291° 43′ of Right Ascension. These points are 10° removed from the points of intersection of the Milky Way and the equator. The pole of this zone is situated in Right Ascension 201° 43′ and North Declination 21°, which is not far removed from the pole of the Milky Way, as determined by Sir John Herschel, viz. Right Ascension 191° 45′, Declination + 27°.

The remaining two papers, which constituted the only number of the "Recherches" ever published, were entitled "Sur le Calcul de l'Orbite elliptique ou parabolique d'après un grand nombre d'Observations," and "Développement de la fonction perturbatrice en série." A brief abstract of the last paper was published in vol. xxi. of the *Monthly Notices*.

After this period Kowalski does not appear to have devoted

himself much to theoretical astronomy. During his later years he was occupied in the observations of circumpolar stars between +80° and the Pole, which sedulously engaged him until 1869, when he joined in the zone observations of the "Astronomische Gesellschaft," undertaking the zone between +75° and +80° Declination. The reduction of these observations was completed in 1883, and the printing, which was then begun, has already made considerable progress.

Kowalski was endued with great energy and power for work, but characterised by a modesty which made him shrink from publishing his works until he had severely criticised them.

From the interesting account of his life given in the *Vierteljahrsschrift* of the "Astronomische Gesellschaft" we learn that Kowalski has left much valuable scientific work which has not been published. The ability and conscientiousness displayed by him in all his researches are an assurance that astronomy would be greatly enriched by their publication.

An affection of the heart, from which he had suffered for some years, suddenly terminated his life on July 9, 1884.

He was a corresponding member of the St. Petersburg Academy of Sciences, and honorary member of the St. Petersburg University.

He was elected an Associate of this Society on November 13, 1863.

Johann Friedrich Julius Schmidt, Director of the Observatory at Athens, whose death was briefly announced in the last Annual Report, was born at Eutin, in Oldenburg, on October 25, 1825. At a very early age his friends soon perceived that he possessed a great inclination for astronomical pursuits, and scarcely had he entered his teens before he gave decided indications of those talents for quickness and acuteness in observing which have marked his scientific career throughout his life. What perhaps encouraged young Schmidt at this early period more than anything else in his enthusiastic taste for the observation of natural phenomena, and more especially for those relating to the physical features of the lunar disk, was the accidental circumstance that when only fourteen years old a copy of Schroeter's work on the Moon, *Selenotopographische Fragmente*, came by some means into his possession. The perusal of this work produced on his mind an intense desire to study on his own account, at some future time, the various peculiarities of the shadow-throwing hills and craters; and to this early influence we must attribute the origin of that life-long devotion which he afterwards gave to the subject of selenography. Fortunately for the young student at this commencement of his career, his father happened to have a small low-power telescope, and with this instrument, attached to a lamp-post, Schmidt made, in 1839, his first attempts at sketching some of the more prominent craters and their surroundings. For a year or two he had no

other instrumental assistance; but imperfect as his telescope was, it afforded him much pleasure and increased his enthusiasm for lunar sketching. Nearly all his spare time was now devoted either to the examination of Schroeter's work or in observing with his small telescope, the mounting of which he had, however, soon improved by constructing for it a rough wooden stand, so that his observations were greatly facilitated. The lunar sketches young Schmidt had made with this small telescope at the beginning of his career were comparatively much rougher than the more finished drawings executed in later years under more favourable circumstances, but they were of great advantage to him at the time, for they were the means of giving him most excellent practice as a student, both in the education of his eye and in the power of delineating the more delicate portions of the Moon's surface. But Schmidt himself knew well that these early observations, having been made under many difficulties, and with so small a telescope, must naturally have been inferior to those made in after years, and he was therefore probably wise in ultimately rejecting them in the final formation of his lunar map.

Through the kindness of a gentleman who had noticed the youth's great zeal for astronomy, and that he was evidently encumbered with many practical difficulties, Schmidt procured, in 1841, the loan of a 4-feet Dollond Telescope, having a power of 15 to 20. This addition to his instrumental means enabled him to prosecute his researches with increased success. Soon after this he became a student at the Gymnasium at Hamburg, but at the same time he never failed to avail himself of every opportunity to continue his observations. This predilection for the study of lunar objects received a great stimulus during a visit, in the month of July 1841, to the Altona Observatory. Here, under the guidance of Dr. Petersen, Schmidt saw the Moon, for the first time, in a larger telescope. It was, therefore, at the Altona Observatory that he first obtained a fair notion of the wide field of inquiry still open to the observer of lunar objects; for not only was he captivated by the telescopic appearance of the craters of *Gassendi*, *Bullialdus* in the *Mare Nubium*, and other prominent objects which Dr. Petersen showed him, but he also had an opportunity of inspecting, also for the first time, the celebrated chart of Beer and Mädler, which in the future was destined to serve as what may be fittingly termed his working lunar catalogue. While a resident in Hamburg Schmidt was a frequent visitor at the Hamburg Observatory, when, through the courtesy of Dr. Karl Rümker, the instruments were occasionally placed at his service for the prosecution of his lunar observations. This permission proved to have been a great boon to the young student, as it enabled him, when necessary, to view the details on the Moon's surface with a higher power than that to which he was usually accustomed.

In 1845 Schmidt, then about twenty years of age, left Hamburg

to accept the appointment of assistant to Professor Benzenberg, who had established an Observatory at Bilk, near Dusseldorf, principally for the purpose of observing occasional astronomical phenomena, but more particularly of shooting-stars and other naked-eye objects, a class of observation in which Schmidt, as well as Benzenberg, was at the time specially interested; and also for the systematic search for supposed intra-Mercurial planets, a subject suggested by the recent publication of Le Verrier's researches on the theory of *Mercury*. Schmidt's lunar observations at Bilk were, however, of a negative character, for during his connection with that Observatory he was able to make only a very slight progress in his sketches of the Moon. This partial cessation of his favourite employment was not owing to any relaxation of energy on the part of Schmidt, but rather to the inferior instrument placed at his disposal for his own peculiar work; for it has been stated that Professor Benzenberg was so careful of his principal telescope that he feared that its outward good looks and polish would suffer had he permitted the young ardent astronomer to use it. Schmidt's connection with the Bilk Observatory was, however, very short, as on the death of Professor Benzenberg in the following year he transferred his services to the Bonn Observatory, where he remained under the direction of Professor Argelander till the year 1853. While an assistant at Bonn, Schmidt made good progress with his lunar researches, without neglecting the usual duties of the Observatory. In these he took his regular share of work, including observations of the positions of small stars for insertion in Hour V. of the Berlin Academy star-charts, as well as of new planets and comets and their comparison stars. Among the comets observed by Schmidt at this time we may refer to the observations of those of Mauvais and Brorsen, published in the *Astronomische Nachrichten* for 1848, and of Peterson and Goujon in 1849. Besides these comets he observed many others, the results of which have been communicated from time to time to the same periodical, including observations of the comets of Klinkerfues and Bruhns. A very important series of drawings of *Saturn* was made by Schmidt in 1848, at the time of the Saturnian equinox, consisting of seventeen sketches of the planet at about the time of disappearance and reappearance of the rings, the principal features in which indicated the possible existence of great inequalities of surface on the rings not previously observed. He also, while at Bonn, formed one of the German party of astronomers who selected Eastern Prussia as their place of observation of the total solar eclipse of July 28, 1851. His account of the eclipse was published at Bonn in 1852 under the title of "Beobachtung der totalen Sonnenfinsterniss zu Rastenburg," extracts from which may be found in Mr. Ranyard's collation of the observations made during total solar eclipses contained in the Society's *Memoirs*, vol. xli.

On the recommendation of Professor Argelander, Schmidt

was appointed in 1853 to take the direction of the Baron von Unkrechtsberg's private Observatory at Olmütz, in Moravia, where he continued his sketches of the lunar features—craters, rills, mountain ranges, &c.—accompanied by numerous micrometrical measurements. Here he remained till 1858. During a visit to the south of Italy in the months of March and April 1855, he took that opportunity of making special lunar drawings, first with the great Refractor at Rome, and afterwards at the Observatory at Naples.

On December 2, 1858, Dr. Schmidt entered upon his duties as director of the Observatory at Athens, where he remained in full activity as an astronomical observer of great reputation to the end of his life. He found this slightly-endowed Observatory in far from flourishing circumstances, and some time elapsed before he was able to bring the 6-feet Refractor by Plössl into a satisfactory adjustment. This preliminary work occasioned some unavoidable delay in his lunar researches, now far advanced; but when his instrument was brought again into working order, he soon made considerable progress, though a large portion of his observing time was devoted to the observation of variable stars, comets, meteors, and other miscellaneous phenomena, of which the resulting observations have been usually printed in the pages of the *Astronomische Nachrichten.* Some of Schmidt's cometary observations have, however, appeared in his "Astronomische Beobachtungen über Cometen," which forms Series 1, vol. i. of the "Publications de l'Observatoire d'Athènes." The results of his observations of extraordinary meteors were, in 1867, published in an octavo volume, entitled "Ueber Feuer-Meteore, 1842 bis 1867." During the latter period of his lunar researches, knowing that the end of his preparatory labours, in anticipation of the formation of his long expected chart, was now approaching, most of Dr. Schmidt's time was devoted to the re-examination of what he had already done, and in filling up those portions of the chart which had hitherto been neglected, a work which necessarily occupied several years. At the same time he was always ready to pick up any new object visible to the naked eye, for he was a constant watcher of the heavens, and a new star or comet was rarely known to appear suddenly without its being soon detected by the keen and sensitive eyes which he was known to possess. In illustration of his knowledge of the constellations, as well as of his watchfulness, we need only refer to his early independent detection of the outbursts of the interesting variable stars T *Coronæ*, which suddenly appeared in May 1866, and *Nova Cygni*, which as suddenly became visible to the naked eye in November 1876. The former variable was observed first by Mr. Birmingham on May 12, and secondly by Dr. Schmidt on the following day; while the latter was first noticed by Schmidt, who made almost daily comparisons of its relative brightness from the day of the discovery of the outburst, November 24, to the middle of December, the magnitude

of the star during this period of three weeks having gradually diminished from the third to the seventh. This continuous series of comparisons of *Nova Cygni* was a very important one, as owing to some delay in making the outburst known to other observers, coupled with cloudy weather, Dr. Schmidt was the only person who had the good fortune to witness the star when at, or near, its maximum brilliancy.

Among the various astronomical labours of Dr. Schmidt, his celebrated chart of the Moon, for the most part completed in 1868, though not finally revised till July 1874—thirty-five years after his youthful determination in 1839 to undertake so extensive a work—will ever remain as the most permanent memorial of the great patience and energy displayed by him throughout this long period, which eventually enabled him to present to his astronomical colleagues this important contribution to selenography. Excellent, however, as the chart is, it would not be correct to say that it is perfect; on the contrary, many serious defects may be easily pointed out, including unavoidable faults arising from the reproduction of the chart by means of photo-lithography, a process that would effectually perpetuate all roughness of drawing, the defects of handwriting, or any injury that might have been caused to the delicate portions of the chart after the eight or nine years' working of Schmidt at the sections. In fact, the parallel and meridian lines on the map were obliterated by this cause, and an attempt was made in 1874 to restore them, but owing to the roughness of the surface of the paper, it was found that this could not be done satisfactorily. From the absence of these lines it is not possible to determine the exact positions of the different objects, which can only be inferred approximately from the graduations on the margin of the map. The photo-lithographic copies also show very clearly that the fainter portions of the lunar markings are greatly exaggerated, for there is not much distinction between the relative intensity of these and the darker mountainous ranges. This important defect becomes very apparent on comparing one of the sections with the corresponding one in Lohrmann's chart, which has been engraved on copper-plate. But, notwithstanding these and other serious blemishes, the whole chart as it stands, with its volume of descriptive text, still remains as a most creditable production by one person, though it be the result of a life-long labour. Dr. Schmidt, in the title to his work, names the map as a chart of the lunar mountains. It is divided into twenty-five sections, each complete in itself, with the usual graduations at the edges, to make it more convenient for reference to the positions of the various objects.

For some time before the completion of the chart, rumours were circulated among astronomers that it was very doubtful whether the results of all this labour of Dr. Schmidt would pass out of the manuscript form, owing to the small endowment of the Athens Observatory. It was evident that the Observatory

had no funds available to bear the expense of publishing the map in its entirety. But it was the opinion of many of those most interested in lunar work, that the chart ought to be in the hands of astronomers generally as soon as possible. On this ground the subject of finding means for its publication in England was discussed by a few of the Fellows of the Royal Astronomical Society, who were also very desirous that the results of Dr. Schmidt's labours should not be lost to the science. He was accordingly requested to forward an estimate of the probable expense of transferring the map upon stone by photo-lithography, or by any other method. Dr. Schmidt, however, proposed pecuniary conditions which, under the circumstances, were impossible to be entertained, and thus the question of publishing the chart in England was given up with regret. Fortunately for science, Dr. Schmidt, during a visit to Berlin in 1874, exhibited his chart at the Observatory, where it excited much admiration among scientific men, which eventually resulted in arrangements being made for its publication under the auspices of the Prussian Government. The Crown Prince was much impressed with the appearance of the chart, and used his influence in its favour with success. It was decided by the authorities that the twenty-five sections, of which the map was composed, should be photo-lithographed at the General Staff Office, under the direction of the Count von Moltke, from the original drawings of the chart as finally completed by Dr. Schmidt. The work was published at Berlin in 1878, under the title of "Charte der Gebirge des Mondes nach eigenen Beobachtungen in den Jahren 1840–1874. 25 Sectionen und Erläuterungsband," folio and quarto, containing the results of a series of more than a thousand drawings, and three times that number of measures of heights, omitting, as we have before stated, most of the sketches made previously to 1842, as these were not employed in the construction of the chart, on account of the first few years' observations having been considered by Dr. Schmidt to be comparatively imperfect. In addition to Schmidt's own lunar work, he also found time to prepare for publication Lohrmann's "Mondcharte in 25 Sectionen," of which only four had hitherto been published in the first part of Lohrmann's work. The unpublished sections came into his possession in an incomplete state many years ago, when he at once announced his intention of publishing them. But, owing to his time having been fully occupied on the revision of his own chart, he was unable to complete them for publication till 1875, which is the date given at the end of the preface. To this work he contributed the descriptive text, consisting, however, only of a very brief statement of the formations included in the sections. It was published at Leipzig in 1878.

The following extract from an interesting review of Dr. Schmidt's labours, written in 1879 by the late Mr. Birmingham, of Tuam, gives in few characteristic words an epitome of the difficulties and successes experienced by the distinguished astro-

nomer. It will form an appropriate conclusion to our brief remarks on his lunar researches: "In even a cursory examination of Schmidt's map, its completion by a single observer must seem almost incomprehensible to a man of ordinary powers; but it requires protracted study to well realise the extent of the work. Any person who tries with the aid of a six-feet telescope to give closely detailed delineation of even a small area of the Moon, will soon conclude that the period of thirty-three years was comparatively a very short one for the accomplishment of Dr. Schmidt's great task. It is, in all truth, a performance highly creditable to the age in which we live, and to Teutonic intellect and perseverance. It is a splendid example from small beginnings. We have first, the astronomer, as a youth of fourteen, viewing the Moon with a little telescope, steadied by a lamp-post, and probably the laughing-stock of many a passer-by; afterwards he is found, in maturer years, pursuing his favourite study under more or less difficult circumstances and in different countries, until, at length, as director of a national Observatory, he completes the wonderful production of his truly inimitable labours. For this it required all the unswerving persistence that is ever a chief attribute of genius; and the pages of the *Astronomische Nachrichten* and other scientific publications can testify to the large amount of other astronomical work performed by Dr. Schmidt simultaneously with his lunar researches." (*The Observatory*, vol. iii. p. 16.)

Of Dr. Schmidt's miscellaneous astronomical observations, it is not necessary to say more in this place than that he was an indefatigable observer of double stars, variable stars, nebulæ, Sun-spots, the markings on the surfaces of the planets and the times of their rotation, meteors, the zodiacal light, and the physical appearances of comets, of which those of Brorsen, Tempel II., and Encke, described in the *Astronomische Nachrichten* for 1868, may be specially referred to. Dr. Schmidt's papers in this astronomical journal extend over a period of forty years, the title of the first memoir inserted in the Royal Society *Catalogue of Scientific Papers* to 1873, being "On the Periodicity of the Variable Star δ *Cephei*," contained in vol. xxi. for 1844. In this Catalogue the titles of 138 papers are given. In the ten following years this number must have been very considerably augmented.

Dr. Schmidt was admitted an Honorary Doctor of the University of Bonn, on the occasion of the foundation festival held in 1868, and he was elected an Associate of the Royal Astronomical Society on January 9, 1874. He continued in the full activity of his labours, and retained his character for acuteness for observing to the last. The same number of the *Astronomische Nachrichten* which contains the results of his last observations of variable stars, made during the year 1883, also gives his obituary notice. Dr. Schmidt had attended a reception at the German Embassy, at Athens, on the evening of Wed-

nesday, February 6, 1884, apparently in his usual health. On the morning of February 7 he was found dead in his bed, having expired suddenly some time during the night. Universal regret was expressed throughout the city on the announcement of his sudden death, and his funeral was fitly made one of national mourning, the King and Queen of Greece attending at the Observatory during the delivery of the funeral oration. At the time of his death Dr. Schmidt was in the fifty-ninth year of his age.

E. D.

Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received by the Council from the Directors of the several Observatories.

Royal Observatory, Greenwich.

The regular meridian observations of the Sun, Moon, planets, and selected stars have been continued in the past year, the whole number of transits observed in 1884 being 5,362, and of meridian zenith distances 4,758. About 1,520 stars were observed in the course of the year, and as the working catalogue is now nearly cleared off, a new list of about 380 stars of the sixth magnitude, which had been omitted, has been incorporated with it. In the preparation of this list use has been made of the recently published "Harvard Photometry," with a view of making the forthcoming Greenwich catalogue of stars down to the sixth magnitude as complete as possible.

In order to determine the personal error depending on the direction of measurement or of motion relatively to the observer, a "reversion-prism," as used by Mr. Gill, has been adapted to the Transit Circle and the collimators. In the determination of collimation error, the difference in the results has been found to be in every case insensible when, by means of the reversion prism, a movement of the wire towards the right is apparently converted into a movement towards the left, or upwards or downwards; but in the observations of transits there appears to be a well-marked personality depending on whether the star's apparent motion is towards the left or towards the right. It is to be remarked, however, that the observers have not yet had sufficient practice in the observation of the reverse motion for quick-moving stars to admit of trustworthy determination of their personal equations in these novel conditions.

The chronograph has lately required cleaning and general repair, and Messrs. E. Dent & Co. have taken advantage of the opportunity to make various alterations suggested by experience. The transits since January 7 have therefore been observed by eye and ear, and materials are thus being obtained for a determination of personal equations in eye and ear transits.

Since last October transits of the close circumpolar stars have been taken at the middle wire set to successive revolutions

of the R.A. micrometer instead of at the successive wires of the chronographic system, the intervals of which are not close enough to allow of a sufficient number of separate observations being obtained in a moderate time. The equality of successive intervals of the R.A. micrometer screw has been recently tested by means of the south collimator for each revolution through a range of twelve revolutions, and also for every tenth of the three middle revolutions, and the errors of the screw are found to be less than the uncertainty of the determinations.

The mean error in R.A. of Hansen's Lunar Tables with Professor Newcomb's corrections is $+0^{s}{\cdot}02$ for the year 1884, as deduced from 104 observations with the Transit Circle.

The flexure of the Transit Circle, as found by means of the collimators, has again apparently changed sign. The resulting value from five determinations in 1884 is $+0''{\cdot}18$, agreeing closely with the mean of the values found in the period 1879 to 1882, whilst the mean of five determinations in 1883 gave the value $-0''{\cdot}49$. No flexure correction has been applied since the beginning of 1879. The apparent correction to the Nadir observation indicated by the mean of reflexion observations of stars in 1884 is $-0''{\cdot}36$, being slightly less than for the previous year.

The observations of the Moon with the Altazimuth have, as before, been confined to the first and last quarters in each lunation. A reversion-prism has also been applied to this instrument.

With the Reflex Zenith-tube, the observations of γ *Draconis* for determination of the temperature correction have been continued, and 39 transits have been observed at temperatures ranging from 57° to 72°.

The dome for the Lassell Equatorial was completed by Messrs. T. Cooke & Sons at the end of last March, but the instrument has only recently been got into working order, as a number of repairs and alterations were required, which have necessarily occupied much time. Amongst other things an improved edge suspension of the mirror has been contrived. This consists of a steel band encircling the edge of the mirror, and supported by brackets at six equidistant points of its circumference in such a way as to distribute the strain whatever part of the mirror may happen to be lowest. Unfavourable weather and difficulties with the driving clock, slow motions, &c., have so far prevented our obtaining any satisfactory micrometer measures of the satellites of *Saturn* with this instrument.

Comet (*c*) 1884 has been observed on four days, the Lassell Reflector or one of the other Equatorials being employed, and some measures of distance and position-angle of double stars, as well as a large number of observations for determining the value of one revolution of the screw in different parts of the field, have been made with the Airy Double-image Micrometer, mounted on the Sheepshanks' or Simms' Equatorial. Twenty-

two occultations of stars by the Moon (including seven disappearances and nine reappearances of faint stars, observed with five different instruments during the lunar eclipse of October 4) and 51 phenomena of *Jupiter's* satellites have been observed during the past year. The occultation of *Venus* by the Moon on February 29 last was observed with two instruments.

The following spectroscopic observations have been made with the Half-prism Spectroscope mounted on the S.E. Equatorial:—674 measures of the displacement of the F line in the spectra of 48 stars; 49 of the *b* lines in the spectra of 12 stars, eight of the F line in the nebula of *Orion*; together with 132 comparisons of the hydrogen or magnesium lines with the corresponding lines in the spectrum of the Moon, or of the sky, several measures of the displacement of the F and *b* lines in the spectra of *Venus* and *Mars*, and some observations of the relative displacement of the F and *b* lines at the E. and W. limbs of *Jupiter*, as a check on the general accuracy of the results for star motions.

In April last the photoheliograph was adapted, by means of a new secondary magnifier (similar to that applied to the instrument at Dehra Dûn), to take photographs on the scale of 8 inches to the Sun's diameter. These large-scale pictures are found to be quite as satisfactory in regard to definition as those of 4 inches, and show much more detail of the Sun's surface.

In the year 1884, 445 photographs were taken at Greenwich on 156 days, the record being not so complete as usual, owing partly to the loss of several days during the adaptation of the new secondary magnifier and subsequent adjustment of the instrument, and partly to a failure of the supply of dry plates in July last. The Greenwich photographs have been supplemented by photographs received from Dehra Dûn for the period 1884 January 1 to November 28, thus making a total of 281 days out of 334 days on which we have photographs available for measurement.

The maximum of solar activity, both in Sun-spots and faculæ, appears now to be definitely past, and the same may be said of magnetic activity, which has been much less marked in 1884 than in either of the two preceding years.

The reductions of all the above-mentioned observations are in a very forward state.

The volume of "Greenwich Observations" for 1882 was distributed in June last, and the printing of the astronomical portion of the volume for 1883 is complete, with the exception of the Introduction. The printing of the Photographic Results, as well as of the Magnetic and Meteorological Results, for 1883 has been somewhat delayed by some additional investigations, but it is now well advanced.

On January 1 the public clock and other mean solar clocks were put forward twelve hours so as to show Greenwich civil

time starting at midnight, and reckoning from 0^h to 24^h, which would correspond with the Universal time recommended by the Washington Conference. The change from astronomical to civil reckoning has also been made in all the internal work of the Observatory, and has been carried out without any difficulty. Greenwich civil time is found to be more convenient on the whole for the purposes of this Observatory, but in the absence of a general agreement amongst astronomers, it has so far been only adopted provisionally, and has not yet been introduced into any printed observations. The change from civil to astronomical reckoning is so easily made that we are quite prepared to use the old or the new time in the "Greenwich Observations, 1885," as may be judged most expedient when the printing of these observations is commenced at the beginning of 1886.

The Observatory has during the past year lost the valuable services of Mr. Dunkin, who retired on August 25, after an honourable connection of forty-six years with the Royal Observatory. Mr. Dunkin has been succeeded in the post of Chief Assistant by Mr. H. H. Turner, B.A., of Trinity College, Cambridge.

Armagh Observatory.

It was announced, in last year's report, that the Lords Commissioners of the Treasury had inserted on the estimates for the year the sum of 2,000*l.* as a grant towards the maintenance of the Armagh Observatory. The grant was paid in August last, the Governors having previously executed a declaration of trust, pledging themselves to spend at present only 1,000*l.* on a new instrument, and to allow the remaining 1,000*l.* to accumulate until the original sum of 2,000*l.* had been recovered, after which time the interest of the whole amount may be spent at the discretion of the Governors for the purposes of the Observatory.

It had at first been intended to order a "Siderostatic Telescope" of the construction indicated about a year ago by Mr. Grubb, but as it was impossible at the same time to procure a second instrument to observe the northern part of the heavens (which would be out of reach of the Siderostatic Telescope), the idea was reluctantly abandoned, and a 10-inch Equatorial Refractor, of Mr. Grubb's well-known form, was decided on as meeting every requirement. It will be erected in a detached building of iron and wood, 15 feet in diameter, surmounted by a dome of iron framework, covered with papier-mâché. The expense of the dome will be borne by a fund subscribed two years ago to erect a scientific memorial to the late Dr. Robinson. The foundation of the building and the pier of the instrument

were built last autumn; the dome is to be ready in April next, the telescope in June.

The new catalogue of stars is going through the press.

Cambridge Observatory.

The number of transits observed with the Meridian Circle during this year amounts to 3,195, most of which were observed at five or seven wires, and all were read off with the four microscopes of the West Circle. These include 2,433 observations of stars, nearly all of which are in the zone between 25° and 30° of North Declination; 611 observations of Clock Stars, and 151 observations of *Polaris*, 73 of which are above the Pole and 78 below. *Polaris* is usually read off three times at each transit—viz., near the first wire, near the centre wire, and near the last wire, thus furnishing a good determination of the inclination of the wires.

In addition to these the requisite number of observations were made for level and collimation, and for obtaining the Nadir point. All this has been the work of two observers, with occasional help from a third.

One of the observations of the Nadir point was interrupted for a while by a singular circumstance. On the morning of April 22 Miss Walker had prepared to make the observation, and was looking into the eye-piece, when she perceived that the image of the wire, instead of being steady, was making violent oscillations. She found it necessary to wait for several minutes before the image became sufficiently steady to allow the observation to be made. It was not till afterwards that she was made aware that a slight earthquake shock had taken place at the exact time when she was attempting to make the observation.

To obtain a more accurate determination of the errors of division of the West Circle in the transit, an extensive series of comparisons with the East Circle was made in June, October, November, December 1883, and in January and February 1884. The East Circle, which is movable relatively to the tube, was clamped at each single degree throughout the quadrant, and its readings in each of the ninety positions were compared with the readings of the West Circle when the telescope was pointed to the Pole, to the Zenith, to the positions of *Polaris* above and below the Pole, to every fifth degree southward from the Pole up to 85° Polar distance, and to each single degree between 60° and 65° N.P.D., the limits of our zone. The largest relative errors were found to be at 15° and 50° N.P.D., where the readings of the West Circle require to be diminished by almost exactly 1″, supposing the reading at the Zenith to be correct. The greatest positive correction on the same supposition is at 85° N.P.D., where the mean of the microscopes ought to be increased by 0″·4.

The standard stars are completely reduced up to the end of 1883, and the coefficients for instrumental correction are obtained near the end of 1884. The reductions of the other stars are progressing satisfactorily.

Fourteen observations of the Comet Wells, made in May 1882 with the Transit Circle, were completely reduced, and the places forwarded to Dr. E. von Rebeur, of the Carlsruhe Observatory, who is engaged on an investigation of the orbit. He was also furnished with places obtained by comparisons of the comet with neighbouring stars, by means of the Northumberland Equatorial.

Two stars required by Professor Newcomb, in his determination of the mass of *Jupiter* from the motion of *Polyhymnia*, were found in the Cambridge zones; one observed twice, the other three times.

Of three stars required by Mons. Bossert, of the Paris Observatory, by letter dated 1884 October 29, two were found in the zones; one observed twice, the other once.

The places of ten stars, compared with Pons' Comet, were furnished to Mons. L. Schulhof on 1884 December 11.

Dunsink Observatory.

The fifth part of the *Dunsink Observations and Researches* has been issued to astronomers during the past year. It contains: I. Observations in Search of Stars with an Annual Parallax. II. Further Researches on the Parallax of 61 *Cygni*. III. On the Annual Parallax of Groombridge 1618. IV. On the Annual Parallax of P III. 242. V. On the Annual Parallax of 6 *Cygni* (B).

During the past year the Meridian Circle and chronograph have been devoted to the observation of southern stars included between 2° and 23° South Declination.

The majority of the stars on the working list still requiring observation when the year commenced were situated in the summer portion of the heavens, and, owing to the cloudiness of the weather in general during the summer months, most of these have again eluded observation, and the latter part of the year has been chiefly devoted to filling up gaps at long intervals in the working list.

The number of Right Ascensions observed is 343, and of Declinations 323; all of which, except a few of the more recent ones, have been reduced to their apparent places for the date of observation.

The clock correction has been determined by observations of standard stars from the *Berliner Jahrbuch*; and of these, 258 transits have been observed, the zero of Declinations being on every occasion determined by Nadir observations from a mercury

trough. The Nadir point has been thus determined 132 times, the errors of runs 78 times, the collimation error 144 times, and the level error 94 times.

The stars observed from September 1882 to March 1884 have, during the year, been reduced to their mean places, and the reduction of the observations made since the latter date is proceeding.

In addition to those mentioned above, when possible, observations were made of transits of standard stars to determine the clock error in connection with the time service to Dublin.

During the total lunar eclipse of October 4, observations of fourteen occultations were made with the south Equatorial in connection with the chronograph. Owing, however, to the invisibility of the dark part of the disk till the moment of total obscuration, it was possible to observe only two stars both at immersion and emersion. The results of these observations have been sent to Professor Otto Struve, but have not yet been published.

Royal Observatory, Edinburgh.

During the past year, true time, as obtained by star observations with the transit instrument, has been distributed from this Royal Observatory, daily, by electric time-ball, time-gun and controlled clocks.

The bi-diurnal observations at fifty-five stations of the Scottish Meteorological Society have also been computed here, and the results arranged for the Monthly and Quarterly Reports printed at regular intervals by the Registrar-General of Births, Deaths, &c., in Scotland.

A correspondence with the Government has been commenced by the Royal Society of Edinburgh, on the subject of printing the remaining portion of the Edinburgh Star Catalogue, but at present without any result.

Glasgow Observatory.

The operations at the Glasgow Observatory during the past year have been chiefly devoted to observations with the Transit Circle of a select list of telescopic stars suspected of proper motion. It is intended hereafter to devote more of the time available for observing purposes to operations with the Equatorial. Due preparations were made for observing the total eclipse of the Moon of October 4, in accordance with the terms of a letter relating thereto received from M. Otto Struve previous to the occurrence of the phenomenon; but the carrying of the project into effect was entirely frustrated by the unfavourable state of the weather.

Kew Observatory.

The sketches of Sun-spots, as seen projected on the photoheliograph screen, have been made on 185 days, in order to continue Schwabe's enumeration. Spots were found on the Sun's surface on each of the above days.

A few experiments were made in June with the photoheliograph, with a view of testing the suitability of certain plates prepared by Messrs. Morgan & Kidd for solar photography. With this exception nothing has been done in that branch during the year.

Transit Observations.—Frequent observations of both solar and sidereal transits have been made, for the purpose of keeping correct local time at the Observatory.

By the courtesy of Mr. Preece, Superintendent of Telegraphs, the Richmond Chief Post Office was placed in direct communication with the Royal Observatory, Greenwich, on January 22, and enabled to receive the time signal at 10 A.M., when a period of cloudy weather had rendered the true time a little uncertain. Two chronometers conveyed to the Post Office showed, on comparison with the signal, a satisfactory agreement between the times as kept at the two Observatories.

Two additional mean time clocks have been obtained, one of them, a Transit of *Venus* Expedition Clock, Dent 2011, has been lent to the Committee by the Astronomer Royal; the other has been purchased.

The superintendent, after communicating with the directors of the Geneva and the Yale Observatories, prepared a circular specifying the conditions watches must fulfil in order to obtain certificates of the various classes, A, B, and C, which are issued, and the nature of the test to which they will be subjected. This circular, together with the forms of certificates, &c., after revision and approval by the Committee, was printed, and copies forwarded to all the leading watch manufacturers of this country, as well as to the principal journals, many of which very favourably noticed the scheme.

Rating commenced on May 13, and up to the present sixty-six watches have been tried, of which twenty-five were submitted by the owners, and forty-one by the manufacturers or by dealers.

Certificates have been awarded to twenty-three of these watches, and nineteen are now on trial.

The usual magnetical and meteorological observations and reductions, and also the verification of instruments, operations to which the attention of the Observatory is mainly directed, have been carried on as formerly.

Liverpool Observatory, Bidston, Birkenhead.

The meteorological observations, the astronomical observations for time, the daily comparisons of the solar with two sidereal clocks by coincident beats, the communication of time to the port, and the daily comparisons of all the chronometers at the Observatory with the Normal clock, have been carried on in the same way as during former years.

For many years past special attention has been paid to the performance of chronometers with the view of showing the degree of accuracy with which Greenwich time can be carried on by them at sea, when an intelligible and systematic record is kept. During the past year records of the performance of the chronometers on twenty-six more voyages from Liverpool to Valparaiso and back again to Liverpool have been received at this Observatory.

The records from upwards of two hundred voyages of the Pacific Steam Navigation Company's steamers have now been obtained, and there is not a single instance in which failure of performance in the chronometers can have caused any inconvenience of importance. By the method which has been devised for calculating the errors from rates corrected for change of temperature, and the checking of these errors from time to time by land observations, the Greenwich time appears to have been nearly as well known from day to day as the local time at ship could be obtained. The navigating officers appear to take great interest in this method of keeping a record of the performance of their chronometers at sea. On bringing his timekeepers to the Observatory, one of them recently pointed out that by his three chronometers and the time signals at Rio Janeiro and Liverpool, the Lisbon time signal was wrong ten seconds. On examining the records with him at the Observatory it was found that the correct longitude had been used in his calculations for Rio, but through some oversight the old longitude, as given in the *Nautical Almanac* for 1883, had been used for Lisbon, thereby causing an error of $8^s{\cdot}6$. On this correction being applied the longitude obtained from the time signal at Lisbon differed from that obtained from the chronometers by only $1^s{\cdot}4$.

A report on finding the Greenwich time at sea, giving the results for each of three chronometers for one hundred voyages, and containing an example showing for one voyage how the daily records were kept, and how the calculations for change of temperature were obtained, has been published by order of the Mersey Docks and Harbour Board, for distribution amongst mariners. A copy of this report may be obtained by application to the director of this Observatory.

When, a few years since, the formula for calculating the corrections for change of temperature was published it was thought

that nothing further would be required from this Observatory than to supply the necessary data for making the calculations. Subsequently, however, it was found to be desirable that these calculations should be made at the Observatory and the navigating officers instructed in the method of applying the corrections at sea. The Mersey Docks and Harbour Board have allowed this to be done in order to make the subject known, and to show the advantage to be derived from applying corrections for thermal error in chronometric navigation.

Radcliffe Observatory, Oxford.

The Transit Circle has been in regular use throughout the year 1884. The number of observations is as follows:—

Transits	3,133
Circle observations (each requiring the reading of the four microscopes)	3,015

These totals include:—

Observations of the Sun	103
Observations of the Moon	62
Reflexion observations of stars . . .	57
Nadir observations	381

Two observations were made of the time of passage of the Moon's diameter, and ten measures of the vertical diameter were secured in the year. The N.P.D. reductions are finished to the end of the year; the R.A.'s are completely reduced to May 31, the remainder being in a very forward state.

The volume of results for 1881 has been printed and distributed. The copy for press for 1882 is in the hands of the printer, and some proof sheets have been received and read.

The observations for 1883 are being discussed and prepared for press.

The discordance between reflexion and direct observations continues small; and determinations of Nadir reading taken over a range of the screws of more than five minutes of arc show that no serious errors can be introduced into our results from any existing wear in the screws.

The observations of the Moon have been compared with the Right Ascensions and North Polar Distances of Hansen's Lunar Tables, which have been interpolated for the purpose from the *Connaissance des Temps.* The mean excess of Hansen's Tables in longitude over observations, with the mean times computed in the usual way, is $+14''\cdot645$.

Six occultations of stars by the Moon have been observed, in addition to a series of occultations of faint stars during the total

eclipse of the Moon on October 4, observed in concert with other Observatories.

Nineteen observations of phenomena of *Jupiter's* satellites have been made with the extra-meridional instruments.

A telescope by Tulley, with a very good 3¼-inch object-glass, originally given by Sir James South, F.R.S., to the late Duke of Marlborough, has been presented to the Radcliffe Observatory by her Grace the Dowager Duchess as a memento of the Duke's long connection with the Institution as a trustee.

Oxford University Observatory.

During the twelve months which have intervened since the last report, the attention of the staff of this Observatory has been directed almost solely to the photometrical work which has there been undertaken. Out of the stars contained in Argelander's "Uranometria Nova," and not extending much lower than the equator, the relative lustre of only a few now remain to be measured, and these it is expected will be completed by the ensuing Easter.

In the course of this work it became desirable to ascertain the amount of light transmitted through various specimens of glass, or reflected from speculum metal, or from chemically deposited silver, or finally from the surface of glass itself. The results are very interesting as bearing on the relative light capacities of refracting and reflecting telescopes; and the interest is still further increased by the fact that the comparison light is in these investigations an actual star, and not an artificial star formed by the agency of a lamp. Some of these results have already been printed in the *Monthly Notices*, and the remainder are ready for communication to the Society.

The Wedge photometer appears to lend itself readily to the prosecution of such inquiries; and the experience of many thousands of measures made by it has confirmed the expectation of their accuracy, and of the facility of repeating with much exactness measures of stellar lustre made at distant intervals of time.

The research into the existence of evidence of gravitational action among the stars constituting the group of the Pleiades has now been printed in Part II. vol. xlviii. of the *Memoirs* of the Society, and will be published in due course.

The preliminary arrangements for determining with considerable accuracy the co-ordinates of the best known points on the Moon's surface have been completed. In addition to Ptolemy A and Triesnecker B, the positions of which are already given in the *Memoirs*, vol. xlvii., the following six formations have been selected as points of the first order, in respect of accuracy of position—viz. Hypatia B, Posidonius, Pico, Milichius A, Nubium C, and Fracastor E; and to these points as

origins of co-ordinates many other formations will be referred. The work is laborious, and will occupy considerable time.

On the roof of the lecture-room attached to the University Observatory, and originally prepared by the architect for this express purpose, a small subsidiary Observatory has been erected, containing a fine Altazimuth by Simms, and a refracting telescope of 4½ inches aperture, by Cooke, completely furnished with subsidiary apparatus. These are intended for the use of the University students, for whom the larger Equatorial instruments under the domes were found for educational purposes to be too unwieldy.

The director has in every way been ably seconded by the intelligent diligence of the two assistants, Mr. Plummer and Mr. Jenkins.

The Temple Observatory, Rugby.

During the year 1884, the measurement of position and distance of binary and suspected binary stars has been continued; 264 sets of measures of 108 selected stars have been made.

The measures taken during the last four years have been reduced and prepared for printing and will be printed in Part II. of vol. xlviii. of the *Memoirs*.

The Observatory has been opened on 77 nights in the course of the year for the purpose of instruction, which of course has precedence of other work.

Some few measures of the motion of stars in the line of sight have been made with the spectroscope on the Reflector.

Stonyhurst College Observatory.

Besides the usual self-recorded meteorological and magnetic phenomena, which have suffered no interruption from the changes made at the Meteorological Office, the astronomical results are more numerous than in previous years. The Sun has received the most attention, in order that the rapidly changing phenomena of its surface may be studied with the greatest accuracy. A paper on this subject was read at the meeting of the American Association at Philadelphia. Two hundred and eighty-one drawings of the entire solar disk were made during the year on 257 different days, and supplementary observations on ten other days. The chromosphere has been measured on eighty-eight days, and partially observed on five other occasions. On thirty days the spot-spectra have been carefully examined, and more than 200 lines between B and D are found to be affected. Wolf's Comet was observed during the months of October, November, and December, and fourteen positions have

been completely reduced. *Jupiter's* satellites, occultations of stars by the Moon, the lunar eclipse, and the watch for meteors, have all received our attention.

The Sun-spot drawings of 1883 have all been measured, and those of 1884 are now in hand.

In order to facilitate work with the star spectroscope, a new finder, 3¾-inch aperture, has been attached to the Equatorial. This is supplied with illuminating apparatus, and admits of very delicate adjustment.

Mr. Barclay's Observatory, Leyton, Essex.

Vol. v. of *Leyton Astronomical Observations* is in preparation. It is intended that this volume shall contain the results of observations up to the end of the year 1884.

The work includes, generally, observations of double stars, phenomena of *Saturn's* and *Jupiter's* satellites, comets, and occultations of stars by the Moon.

The instruments remain as in former years, but at present Messrs. Beck are making a "Langley" solar eye-piece for the Observatory. This eye-piece is a polarising one.

Mr. Common's Observatory, Ealing.

During the past year a small number of celestial photographs have been taken, including two of the Dumb-bell nebula, and a number of experiments have been made in stellar photography.

The 3-foot Reflector has passed into the hands of Mr. Crossley, of Halifax, at whose Observatory it is now erected. It is intended to replace this instrument with one of 5-foot aperture, made expressly for photography, with a mounting having for the polar axis a hollow iron cylinder floating in water, so as to reduce the friction and vibration of a merely mechanical mounting.

The disk of glass for the large mirror was obtained in 1883, and seems to be all that can be wished for.

The Earl of Crawford's Observatory, Dun Echt.

Some interesting observations were made in the early part o the year of the relatively bright spectrum of Comet Pons-Brooks the returned comet of 1812, which showed four bright bands. The principal bright lines and the great bright band in each of the three Wolf-Rayet stars D.M. $+35°$, 4001, $+35°$, 4013, and D.M. $+36°$, 3956, were also measured on several evenings. The observations

were made with the 12-inch Browning Reflector, some alterations of the eye-end of the 15-inch being in progress. These stars were specially examined in connection with the publication in *Copernicus*, Nos. 35 and 36, of the full report of Dr. Copeland's astronomical experiments in the Andes, in the course of which he detected five objects of this comparatively rare class, besides showing that it probably has its most brilliant representative in *γ Argûs*, which star doubtless offers the most magnificent stellar spectrum permanently visible in the heavens. In the autumn a considerable part of the northern heavens was repeatedly swept with a 6-inch telescope and a prism in front of the object-glass. Four hitherto unnoticed minute planetary nebulæ and one star of the above-mentioned semi-gaseous type were found in this way, as was also Comet Wolf, in advance of the receipt of the news of its discovery in Germany. (*Monthly Notices*, vol. xlv. pp. 90, 91.)

Both phases of the occultation of *Venus* on February 29, and a number of occultations of small stars during the eclipse of the Moon on October 4, were recorded with two telescopes. Late in the year considerable attention was paid to *Saturn* and its spectrum; particulars of these observations, including measures, will be shortly published. The construction of a large spectroscope by Messrs. T. Cooke & Sons, of somewhat special design, is fast approaching completion. Great difficulty has been experienced in obtaining suitable glass for the prisms. Some progress has been made in the examination of parts of the Sun's spectrum with the Rowland grating described in the last report. Ten circulars, all referring to comets, have been issued in the course of the year.

After a long delay the printing of vol. iii. of the Observatory publications has been resumed; it is expected that it will be finished in a few weeks. The Saturday time-gun and daily weather observations have been continued as usual.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

The observations made at this Observatory during the year 1884 were generally similar to those of previous years. Of the phenomena of *Jupiter's* satellites, 66 were observed, 34 of the conjunctions, &c., of the inner satellites of *Saturn*, and 15 occultations of stars by the Moon. These have been communicated to the Society.

The wedge photometer was ready for use early in the year; and on suitable nights it has often been used, and some hundreds of measures, chiefly for the determination of constants and scale, have been made. Many naked-eye observations have also been made of ten selected variable stars.

Mr. A. A. Common's 3-foot Reflector has been purchased, and

mounted in the Bermerside grounds. A suitable dome will soon be placed over it, and with the return of good weather we hope to begin some useful work with this fine instrument.

The Earl of Rosse's Observatory, Birr Castle.

During the year 1884 astronomical observations were made on fifty-two nights.

Twenty-one drawings of *Jupiter* were obtained with the 3-foot Reflector, also fourteen of *Mars*. Thirteen of the latter are in course of publication in the *Transactions of the Royal Dublin Society*.

Measurements of lunar radiant heat were made with the 3-foot Reflector, principally in connection with the eclipse of October 4. A short preliminary account of them appeared in *Nature*, of October 16, and the complete account is now nearly ready for publication. An exceptionally favourable night made this work more satisfactory than could have been expected.

The 6-foot Reflector was employed on nebulæ during the year, and sketches made.

A short note on the polishing of specula and one on a new electric control for an Equatorial clock were read before the British Association at Montreal.

The meteorological observations were continued as usual.

Colonel Tomline's Observatory, Orwell Park, Ipswich.

The past year has not been favourable for the frequent observation of comets, of which four have received more or less attention during the interval under review. The series of observations of Pons-Brooks' Comet was continued until January 28, seven observations being obtained before it passed to the southward. Repeated attempts were made to observe Barnard's Comet, but only once successfully. It was then found to be so faint, and its position so unfavourable for observation in this latitude, that it was evidently advisable to leave the determination of its orbit to more southern observatories. Observations of Wolf's Comet were commenced on September 25, and are still being continued. Unfavourable weather during the later months of the year has rendered the series a shorter one than was hoped for. Thirteen observations fall within the year. Encke's Comet was looked for unsuccessfully on December 15, since which time no favourable opportunity of repeating the attempt has occurred.

The publication of the results of previous work has been persevered in, and will be found in the columns of the *Astronomische Nachrichten*. Observations of Comets III. 1882, and I.

1883 were published on May 13 in No. 2,592, and of Comet I. 1884 on October 21 in No. 2,623 of that journal.

Cloudy weather prevented the observation of the occultations of small stars during the total eclipse of the Moon on October 4 as proposed by Dr. Döllen, for which preparations had been made.

Lieutenant-Colonel Tupman's Observatory, Harrow.

This Observatory has been built and equipped during the past year. Its situation, taken from the 6-inch Ordnance Survey Map, is in latitude 51° 35′ 15″, longitude $0^h\ 1^m\ 20^s{\cdot}0$ west of Greenwich. The building, 45 feet by 20, is of wood, upon a brick and concrete foundation. The roofs over the telescopes run off upon rails, so that these instruments are used in the open air. The shutter-openings of the Meridian Circle are 2 feet wide, and afford a clear meridian from the northern horizon to N.P.D. 122°. There is a photographic developing-room and a chronograph-room.

The Meridian Circle, by Messrs. Troughton & Simms, has a telescope of 3¾ inches clear aperture and 47 inches focal length. The arrangement of the eye-piece micrometers is the same as that at the Royal Observatory, Greenwich, the P.D. micrometer having the same self-recording drums, and the bright-wire illumination is effected by a similar arrangement of internal prisms. The circle is 24 inches in diameter and is read by four microscope micrometers of high power, supported by a massive bronze ring. Their fields are illuminated by means of systems of prisms from a single lamp, with large condensers placed on the prolongation of the axis of the instrument. The instrument can be reversed for observations of Right Ascension, or of collimators, and is provided with a reversing apparatus running on rails between the stone piers.* The collimators, of 1½ inch aperture and 19 inches focal length (doubtless much too small), both provided with micrometers, are mounted in a novel manner on iron pillars, which stand so as to leave the meridian clear for reflection observations, the collimating telescopes moving on hinges on the tops of the pillars. This arrangement seems to possess all requisite stability.

The transit clock, by Molyneux, with steel pendulum rod and mercurial compensation, has been improved by Messrs. E. Dent & Co., and fitted with contact springs and seconds-contact wheel. It is mounted in the dwelling-house, some 50 yards distant from the Observatory. A three-current relay, by Messrs. E. Dent & Co., is worked by the clock circuit.

The chronograph, made by Mr. C. Baker, of Holborn, is a make-circuit Morse recorder, with paper fillet and two pens, which make the records in ink.

* The telescope, transit-clock, and stone piers originally formed part of the equipment of Professor Pritchard's Observatory at Clapham.

There are two Equatorial telescopes. A $4\frac{1}{2}$-inch Refractor, by Messrs. T. Cooke & Sons, standing on an iron pillar with clockwork of their well-known form. A fixed position circle was added by Messrs. Troughton & Simms. This instrument was employed for the observations of the transits of *Venus* in 1874 at Honolulu, in 1882 in New Zealand. It is provided with filar, double-image, crossed bar and ring micrometers, by Messrs. Troughton & Simms. The other telescope is a Newtonian silver-on-glass Reflector of $18\frac{1}{2}$ inches aperture, equatorially mounted and driven by clockwork by Mr. G. Calver, of Chelmsford.

The masonry supporting all the instruments has been sunk 8 to 10 feet into the London clay, and the whole included in a layer of concrete about a foot thick, covering the ground over a space 60 feet by 20.

The $4\frac{1}{2}$-inch Refractor has been chiefly employed on a long series of observations of Wolf's Comet, for place, commencing September 24.

Royal Observatory, Cape of Good Hope.

The present report includes the period 1884 January 1 to December 31. During the year meridian observations have been carried on in accordance with the programme announced in the last report—viz. all stars to 4th magnitude inclusive in the Southern Hemisphere, a selected list of circumpolar stars, all stars of the *Nautical Almanac*, and of the Berlin, Paris, and American Ephemerides to N.P.D. 45°, together with observations of the Sun, *Mercury*, and *Venus*. In addition a large number of comet comparison stars, and stars used for geodetic and other purposes, have been added to the observing list, which will further include stars used in connection with the theodolite observations for Fundamental Declinations.

The following tables show the amount of work accomplished:—

Number of Determinations of Collimation	48
" " Level	423
" " Nadir	447
" " Runs	600

Observations of Stars.

In R.A. Direct.	In R.A. Reflex.	In R.A. Total.	In N.P.D. Direct.	In N.P.D. Reflex.	In N.P.D. Total.
4011	1627	5638	3638	1631	5269

	Direct.	Reflex.	Total No. of Days.
Observations of the Sun {2 Limbs each in R.A. / 2 Limbs in N.P.D.}	70	69	139
Mercury	47	12	59
Venus	69	34	103

During the winter months, observations were made systematically by the same observer in the evening and early morning, so that the same circumpolar stars were observed at both culminations, thus affording fundamental determinations of azimuth. The observations in the second watch of the night were carried on by a second observer. On the following night the duties of the two observers were interchanged. In this way fundamental determinations of the places of all stars of the circumpolar list were obtained.

A re-examination of the micrometer screws of the Transit Circle, instituted in September, shows, that in a period of less than five years (the new screws were applied in March 1880), an amount of wear has taken place which, if not determined and allowed for, would seriously diminish the accuracy of the resulting N.P.D.s, and systematically affect the determination of latitude. The errors of these screws were carefully determined in March 1880, and found to be quite insensible.

The results of the recent investigation show that the different screws have worn very unequally in amount, although the general law of wear is nearly the same for all.

The errors of the Declination micrometer screw have also been rigorously investigated.

For the purpose of determining Fundamental Declinations, the great Indian theodolite has been remodelled in many points by Messrs. Troughton & Simms, under the supervision of H.M.'s Astronomer. Efficient means have been provided for determining the errors of the pivots, and new methods arranged for determining the instantaneous level of the horizontal axis. A new eye-piece micrometer has been contrived; two perfectly symmetrical cones, permitting easy interchange of object-glass and eye-end, have been substituted for the former telescope tube; and there is new central illumination of the field. New object-glasses have been provided for the microscopes of the Horizontal Circle, giving double the magnifying power of the old microscopes, and the illumination of the part of the Circle under observation is effected by small incandescent electric lamps (one for each of the five microscopes), the light of each being reflected to the Circle from a dull-white surface. The accuracy of the Circle readings is now fully three times greater than before. Means have also been arranged for a complete determination of the errors of graduation of the Circle.

An Observatory for the great theodolite has been constructed, with a suitable dome, and which will permit easy equalisation of the external and internal temperatures.

The following observations of comets have been made with the 7-inch Equatorial and Repsold wire micrometer:—

Comet	Pons-Brooks	on 43	nights between	Jan. 16	and	Apr. 29
„	Barnard	31	„	July 24		Oct. 20
„	Wolf	15	„	Oct. 20		Dec. 15

The observations of Barnard's Comet have been communicated to the *Monthly Notices* and *Astronomische Nachrichten*; those of Comet Pons-Brooks will be communicated so soon as the meridian observations of all the comparison stars have been reduced—a work now in progress—the observations having been made in the early mornings before sunrise. Observations of Comet Wolf are still in progress.

Of the occultations, predicted by the *Nautical Almanac* Office for this Observatory, 22 have been observed during the year.

During the total eclipse of the Moon on October 4, the disappearance or reappearance of seven stars of Döllen's list were observed (three of them by two observers), but the night was a very unfavourable one. The results have been communicated to M. Struve.

During leave of absence in England, H.M.'s Astronomer passed through the press the following works:—

1. "Heliometer Determinations of Stellar Parallax." By Gill and Elkin. (*Mem.* R.A.S.)
2. "The Cape Catalogue of 4,810 Stars for the Equinox, 1850."
3. "Results of Meridian Observations, 1879, 1880, and 1881."
4. "Extra Meridian Observations, 1881, 1882, and 1883."
5. "An Account of the Telegraphic Longitude Operations, connecting Aden and the Cape."

Of these Nos. 1 and 2 have been circulated amongst astronomers; the issue of Nos. 3, 4, and 5 is delayed for the sake of some additions.

The printing of the results of 512 occultations of stars by the Moon has been delayed for the sake of including the results of some observations of the occulted stars received since the work was originally prepared for press.

Advantage was taken by H.M.'s Astronomer of his visit to England to represent the necessity for a new and more powerful Heliometer, to enable him to prosecute his further proposed researches on stellar parallax. The proposal was favourably considered by the Lords Commissioners of the Admiralty, and, on their recommendation, the necessary credit was sanctioned by H.M.'s Treasury. A contract has been entered into with Messrs. Repsold, of Hamburg, for the construction of a heliometer of 7 inches aperture, to be completed by February 15, 1887. The construction of the Observatory (of iron, sheltered by open wooden louvre-work), and of a dome (iron frame, covered by papier-mâché), has been undertaken by Mr. Grubb, of Dublin; and plans for the foundation of this Observatory (including a fire-proof record-room) have been prepared in the office of the Admiralty Director of Works.

The geodetic survey of South Africa makes considerable

progress. In Natal the work in charge of Captain Morris, R.E., has been carried on with remarkable energy and skill. The base-line, measured in 1883, near the centre of Natal, has been extended to the first great side (Zwarlkop-Gilboa), in the centre of Natal, and thence by chains of large triangles southwards to Umtamvuna, in the south of Natal, and westwards to Kokstad, in the eastern part of Griqualand East. Astronomical determinations of latitude and azimuth have been made at Zwarlkop and Umtamvuna, and the longitude of Kokstad has been connected with that of this Observatory by telegraphic operations on six nights. Captain Morris is now pushing the triangulation northwards, and expects to complete the principal triangulation of Natal in August of the present year. This will afford the first geodetic result of the new survey—viz. an arc of about $3\frac{1}{2}°$ of latitude, extending from north to south of Natal.

The Volksraad of the Transvaal Republic has voted a sum of 10,000*l.* for commencement of a principal triangulation of the State. H.M.'s Astronomer is in correspondence with Mr. G. R. van Weilligh, Surveyor-General of the Transvaal, and it is hoped that the result will be a friendly co-operation in the general scheme for the geodetic survey of South Africa, and the extension of an arc of meridian from the Natal arc northwards to the Limpopo.

A considerable supply of tidal records is now available; their measurement and discussion are matters which must soon be considered.

The system of time signals remains unchanged.

The meteorological observations, made in the year 1883 at this Observatory, together with those taken in different parts of the Colony, have been printed in the Reports of the Cape Meteorological Commission.

Hong Kong Observatory.

The activity of this Observatory commenced on January 1 with tri-diurnal meteorological observations, monthly absolute magnetic observations, and the issue of daily and monthly weather reports, the former based on telegraphic information received from the Treaty Ports along the China coast and from Luzon. Later on, information was received also from Japan, Wladiwostock, and Tonquin, and full reports and forecasts concerning disturbances were issued daily during the stormy season, and a number of instruments were verified for the observers. The building was finished and all the self-recording meteorological instruments were at work by April 1; and their indications have been tabulated up to date. The transit instrument was erected in April, and meridian marks were subsequently fixed. The instrument was carefully examined, and the observations were

used for rating clocks and chronometers. The large time-ball will be automatically dropped by the mean time clock from January 1, 1885.

The six-inch Lee Equatorial and Sir W. Thomson's automatic tide-gauge, which arrived in the autumn, have not yet been mounted.

Several meteorological papers besides the regular reports have been published in the course of the year, and some progress has been made in the reduction of certain unpublished double-star observations.

Notes on some Points connected with the Progress of Astronomy during the past Year.

Discovery of Minor Planets.

The following nine minor planets were discovered in the year 1884:—

No.	Name of Planet.	Date of Discovery. 1884.	Discoverer.	Place of Discovery.
236	Honoria	Apr. 26	Palisa	Vienna
237	Cælestina	June 27	Palisa	Vienna
238	Hypatia	July 1	Knorre	Berlin
239	Adrastea	Aug. 18	Palisa	Vienna
240	Vanadis	27	Borrelly	Marseilles
241	Germania	Sept. 12	Luther	Düsseldorf
242	Kriemhild	22	Palisa	Vienna
243	Ida	29	"	"
244		Oct. 14	"	"

Up to the present time no fewer than forty-six of these bodies have been discovered by Herr Palisa. Professor C. H. F. Peters has discovered forty-two.

Professor Luther has communicated to the *Observatory* (vol. vii. p. 180) a list of twenty-eight minor planets which have been observed during only one apparition. They are as follows:—

99 Dike	183 Istria	222 Lucia
132 Æthra	188 Menippe	223 Rosa
145 Adeona	193 Ambrosia	225 Henrietta
149 Medusa	197 Arete	228 Agathe
155 Scylla	206 Hersilia	232 Russia
156 Xantippe	208 Lacrimosa	213 Asterope
157 Dejaneira	210 Isabella	234 Barbara
163 Erigone	217 Eudora	235 Carolina
175 Andromache	220 Stephania	236 Honoria
177 Irma		

Of these Hersilia and Isabella have recently been re-observed. The supposed new minor planet, No. 245, the discovery of which was announced by Herr Palisa, on October 27, has been found to be identical with Lacrimosa.

The Comets of 1884.

Five comets have been under observation during the year 1884; brief notes of which are given in the following paragraphs:—

I. *Comet* 1883, II.—This is the comet whose discovery was mentioned in the last Annual Report, and of which it was anticipated that observations would not be possible in these latitudes. It was discovered on January 7 by Mr. David Ross, of Elsternwick, near Melbourne, in 41° South Declination, and gradually diminishing in brilliancy, was last seen on February 4. The elements, computed from the few observations that were possible, show that the comet passed its perihelion on December 25, 1883, so that it should appear in the catalogue of comets for that year. These elements also show that the path of the comet, prior to its discovery, was such that it should have been picked up in this hemisphere. Further, it is seen from this orbit that this comet could not be identical with a bright comet seen in Tasmania, shortly before sunrise on the mornings of December 25 and 27. Unfortunately no accurate observations of this comet were attempted; but the roughly approximate positions point to a northerly motion, which would have soon made the comet visible in Europe.

II. *The Pons-Brooks Comet.*—It is scarcely necessary to add to the notice given last year of this interesting comet of long period. The inconstant form of the nucleus there referred to has since been confirmed by many observers. These rapid and apparently lawless changes, taken in conjunction with the similar phenomena exhibited by the brilliant comet of 1882, very strongly mark the long recognised difficulty of selecting, during a long series of observations, a point which uniformly corresponds with the centre of gravity. The comet is reported to have been last seen on June 2, in New Zealand, but the last accurate observations appear to have been made at Cordoba on May 26, 122 days after perihelion passage. The first observation was made 144 days before perihelion, so that a longer period of observation might have been anticipated, the more so as the theoretical brilliancy at the end of May was 2½ times that at the date of its discovery. Dr. Morrison has obtained elements from some selected positions, which, however, do not embrace the entire period of observation. These elements, in point of accuracy, possess scarcely any advantage over the earlier deduced orbit of MM. Schulhof and Bossert, the close accordance of whose ephemeris with the actually observed path, is acknowledged by Dr. Gould.

III. *Comet* 1884, II.—A comet first seen by Mr. E. Barnard, of Nashville, on the night of July 16, while sweeping in the south-west; but owing to the slow motion in declination and the configuration with neighbouring stars, its cometary character was not detected till the 19th. It differed but little in appearance from the ordinary telescopic comet, and during the whole time of its visibility, up to the latter half of November, it remained an inconspicuous object. The alteration in brightness, as in other comets recently observed, was neither uniform nor consistent with the law of reflected light. The parabolic elements first computed showed some resemblance to those of De Vico's comet of 1844, a comet which, notwithstanding its undoubted elliptical orbit, has not been seen since. This similarity is of the more importance, since later observations, discussed by Dr. Berberich and others, have shown that this comet is moving in an ellipse of short period; but it is scarcely possible that it is identical with De Vico's lost comet of 1844, since the period of forty years does not contain an approximately exact number of revolutions. The period, however, is still very uncertain, Mr. Finlay having given it as 5·6615 years (which would nearly coincide with seven complete periods), while Professor Frisby has given one half a year less. A definite discussion is necessary since the comet can approach the orbits of both *Jupiter* and *Mars*. The closest approach to the latter planet occurs in heliocentric longitude 343° 25′, when the distance is only 0·008, that of the Earth's mean distance from the Sun. Both objects had this longitude in April 1868, when the perturbation was probably considerable.

IV. *Comet* 1884, III.—Discovered by H. Max Wolf, of Heidelberg, on September 17 in the constellation *Cygnus*, but from want of instrumental means, the position of the comet was not obtained till September 20. Dr. Copeland reports that the comet was independently discovered by him at Dunecht, by means of the spectroscope. On September 24 Lieut.-Col. Tupman described the object as a rather bright telescopic comet, showing a stellar nucleus 3″ in diameter, with a faint and diffused coma 2′ in extent. Like the preceding comet, this also belongs to the catalogue of elliptic comets of short period. According to Dr. Krueger, its period is about 2,460 days, but the most interesting fact in connection with the comet is the close approach it must have made to *Jupiter* in May 1875. By direct calculation from the elements, on May 28, 1875, the distance between the comet and planet was only 0·09, and a much closer approach is possible. An attempt has been made by Dr. Lehmann-Filke (perhaps prematurely, considering the uncertainty of the elements, and the neglect of perturbations in the interval) to determine the path of the comet both while in the neighbourhood of *Jupiter* and previously. Accepting his results as approximately correct, the orbit before the perijove differed very materially from that in which the comet now moves, the

eccentricity being only one-half what it now is, while the period was one-third longer. Hence, the perihelion distance is much diminished (from 3·327 to 1·570), which would satisfactorily account for the comet not having been seen at earlier returns. In 1878 the circumstances of the return were unfavourable to observation.

V. *Encke's Comet.*—Re-observed by Dr. Tempel, at Arcetri, on December 13, by means of an ephemeris supplied by Dr. Backlund of Pulkowa. The object was of extreme faintness, and the observation was earlier than might have been anticipated from the circumstances of the somewhat similarly situated return in 1852. The correction to the ephemeris is very small.

In addition to these comets that have been observed, it should be mentioned that Brorsen's comet passed its perihelion in the middle of September, but, it is believed, escaped observation. Unfortunately, no accurate ephemeris was published to assist the re-discovery, and the circumstances for its re-observation were not of the most favourable character, rising as it did about two hours before the Sun in August.

A comet discovered by Tuttle in 1858, but observed only eight times, has recently been the subject of a discussion by M. Schulhof, who has shown that it is another of short period. The mean motion cannot be accurately determined, but corresponds probably to a period of about six and a half years, in which case a return might have been expected in 1884. Sweeping ephemerides have been published, and while searching for it, M. Spitaler observed on May 26 a faint nebula, lying nearly on the path of the comet which has not been seen since. Whether this observation is connected with the missing comet, M. Schulhof considers doubtful, since the comet in that position should have had considerable brilliancy.

W. E. P.

Professor Newcomb's Development of the Perturbative Function.

In the third volume of "Astronomical Papers, prepared for the use of the *American Ephemeris* and *Nautical Almanac*," Professor Newcomb has given an elaborate paper on the Development of the Perturbative Function. Both the method employed, and the mode in which the results are exhibited, present some interesting peculiarities. The analytical developments are expressed in terms of multiples of the eccentric anomalies of the two planets concerned, instead of in terms of multiples of the mean anomalies, which have been more usually employed. The advantage of this is that the co-ordinates of the planets can be far more simply expressed in terms of the eccentric than in terms of the mean anomalies, and that the convergence of the series obtained is much more rapid. When the development in multiples of the eccentric anomalies has been

made, the transformation to mean anomalies is very readily made numerically, by means of Bessel's functions, the application of which for this purpose is fully explained in the paper.

In order to determine the planetary inequalities, it is required to have the development, not only of the disturbing function itself, but likewise that of its derivatives, taken either with respect to the elements, or with respect to the co-ordinates of the two planets. The disadvantage of employing the former derivatives is, that the number of the elements is twice that of the co-ordinates; and, therefore, especially in the cases where it is necessary to take into account the derivatives of the second or higher orders, a much larger number of operations is required to be performed. Besides this, the perturbations of the elements are usually much greater than those of the co-ordinates themselves.

In the present method, the derivatives of any orders, with respect to the co-ordinates, are readily derived from the development of the disturbing function itself. It is, however, necessary to transform the expressions for each derivative from eccentric to mean anomaly separately. It should be remarked that in this paper the disturbing function R is considered as a function of the *logarithms* of the radii vectores of the planets instead of the radii vectores themselves, and that the derivatives are taken with respect to these logarithms accordingly.

Professor Newcomb thinks it probable that in cases where it is necessary to go beyond the sixth power of the eccentricities, or the mutual inclination of the two orbits, a method given originally by Cauchy, and more fully developed by Hansen, will be found more convenient than the present one; and, therefore, the sixth order has been adopted as the limit of the analytical development, although the fundamental formulæ are carried to terms of the seventh order.

At the conclusion of the paper are given tables and very full and clear directions for the practical application of the method.

Professor Newcomb on the Motion of the Seventh Satellite of Saturn.

The same volume of "Astronomical Papers" contains a remarkable paper by Professor Newcomb, entitled "On the Motion of *Hyperion*, a New Case in Celestial Mechanics."

In several papers, published during the past five years, the latest of which is found in the *Monthly Notices* for May 1884, p. 361, Professor Hall has shown, from his own and other observations of *Hyperion*, a remarkable retrograde motion in the perisaturnium of that satellite. He finds that the period of revolution of the perisaturnium is about eighteen years.

At first sight this result appears to be inconsistent with the theory of gravitation. The satellite *Titan* being much the largest and much the nearest to *Hyperion* of all the satellites of *Saturn*, is that by which the motion of *Hyperion* is the most disturbed. But the mean motion of the perisaturnium of this satellite, caused by the action of *Titan*, which is given by the ordinary theory of secular variations, is readily shown to be a direct motion.

In the present paper, Professor Newcomb shows that the difference between this motion, and the retrograde motion given by observation, is caused by a near approach to commensurability in the mean motions of the two satellites.

In fact, four times the mean motion of *Hyperion* is nearly equal to three times that of *Titan*. Now, if l, l' denote the mean longitudes of the two satellites at any time, and ϖ' the longitude of the perisaturnium of *Hyperion*, there will be a term in the motion of this perisaturnium proportional to

$$\cos(4l'-3l-\varpi'),$$

and multiplied by a constant coefficient, which is much larger than those of the terms which give the ordinary secular variation of the perisaturnium. In consequence of the above-mentioned relation between the mean motions, the quantity $4l'-3l$ varies very slowly, and diminishes as the time increases. From this it is not difficult to show that the mean rate of variation of ϖ' is the same as the rate of variation of $4l'-3l$, so that the angle

$$4l'-3l-\varpi'.$$

oscillates about a mean value, which is found to be 180°, and the motion of ϖ' is retrograde. Hence it follows that *Hyperion* and *Titan* come into conjunction with each other only at or near the apo-saturnium of the former satellite. The result thus obtained is fully confirmed by the observations.

The complete investigation of the law of variation of the above-mentioned angle

$$4l'-3l-\varpi',$$

is very difficult, and Professor Newcomb only attempts to obtain an approximate solution, from which he deduces that the mass of *Titan* is nearly equal to $\frac{1}{12500}$ of the mass of *Saturn*, and that the greatest amount of the principal inequality in the motion of the perisaturnium of *Hyperion* is about 10°, and also that the difference between the angle $4l'-3l-\varpi'$ and 180° varies between the limits 18° and −18° nearly.

Professor Safford's Investigation of Corrections to Greenwich Planetary Observations 1762–1830.

Previous to the commencement of accurate observations by Bessel and Struve, the observations made at Greenwich by Bradley, Maskelyne, and Pond, supply almost the only valuable data at the command of astronomers for fixing the positions of the planets between 1750 and 1820. So far as Bradley's observations are concerned, the work of Dr. Auwers may be expected to supply all that is required. In order to utilise the long series of observations made by Bradley's successors, it is now necessary that the work of Maskelyne and Pond should be similarly reduced. For this purpose Professor T. H. Safford has prepared the fundamental formula and tables for the reduction of the planetary observations to the system of Right Ascensions and Declinations adopted in the star catalogues of the *American Ephemeris*, the Declinations being reduced to Boss's system. This work forms one of the important series of astronomical papers prepared for the use of the *American Ephemeris.*

It commences with some brief historical account of the nature of the instruments, and their corrections, used at Greenwich by Bradley, Bliss, Maskelyne, and Pond. The methods of reduction are fully explained. With regard to Bliss's observations, it has been possible to find the instrumental correction of the transit at the Pole, and so to find the probable deviation of the meridian mark. But for the Declinations nothing was attempted. In reducing Maskelyne's and Pond's Right Ascensions the method of Auwers is followed as given in his paper on the Variable Proper Motions of *Sirius* and *Procyon.*

In reducing Maskelyne's Declinations, Olufsen's paper in *Astronomische Nachrichten*, vol. ix., is followed with modifications, such as employing the Pulkowa refractions instead of Bessel's, using the mean declination of Professor Newcomb's catalogue of 1,098 Standard Stars, and in the reduction from mean to apparent place, employing Peters' nutation and Struve's aberration.

The study Professor Safford has made into these observations confirms his view derived from Bessel, that Maskelyne was a good observer in detail, but very negligent in the handling of his instrument. He seems to have been methodical without understanding the importance, which Bradley well knew, of keeping a close watch on the adjustments.

In discussing Pond's Declinations, Professor Safford remarks upon the quadrant then in use at Greenwich, which he infers was a very troublesome instrument to use, and was frequently employed by quite unskilled persons. The plumb-line adjustment of the instrument, he thinks, may have been frequently neglected as too troublesome, or frequently attempted with a disastrous result.

In correcting Pond's Declinations observed with the Trough-

ton Circle alone, a very simple process was sufficient. The slight flexure found by Olufsen in his re-reduction of Pond's observations made with this instrument in 1822, and the fact that the Declinations so determined agree very perfectly with Boss, render it necessary only to correct Airy's index errors for this circle by the reduction from Bessel's Declinations to Boss's.

Tables are appended to the paper, giving differences of mean Right Ascension between Newcomb and Le Verrier of Maskelyne's 36 principal stars for the epochs 1760, 1800, 1840; corrections to the *Tabulæ Regiomontanæ*; instrumental corrections for the years 1762 to 1830 inclusive, chiefly for those times only in that period when planets were observed; corrections to the stars' declination necessary to reduce to Boss; mean declinations of 8 stars in *Gemini* and β and γ *Draconis*, for every 10 years from 1760 to 1810; empirical corrections for the quadrant for the fundamental stars south of *a Geminorum* inclusive, from 1767 to 1787; observations of fundamental stars, 1765 to 1812, corrected approximately for errors of the quadrant; and concluded constants for correcting the quadrant, compared with Olufsen's constants.

The Cordoba Zone-Catalogue.

The private expedition to South America, originally planned by Dr. Gould, had for its object the completion of the general revision of the whole heavens by zone observations similar to those which had been carried out, in the northern hemisphere, by Bessel and Argelander. These extended from 80° of North to 30° of South Declination, and it was known that similar observations around the South Pole had been made by Gilliss while at Santiago de Chile in 1851 and 1852, although these remain even now unpublished. Dr. Gould's original design was to extend his scrutiny of the southern heavens from 28° to 70° of South Declination; but at the strongly expressed desire of Argelander, the northern limit of the Cordoba zones was placed at 23°, and, despairing of an early publication of the zones near the South Pole, the southern limit was transferred to 80° instead of 70° South Declination. This private expedition was, before being carried into effect, adopted by the Argentine nation and became the germ of its National Observatory; and thus it is that this extensive and valuable zone-catalogue, honourable alike to Dr. Gould and to the Argentine nation, appears as a publication of the Argentine National Observatory. In this catalogue there are printed 105,240 separate observations reduced to the epoch 1875·0, giving the positions of 73,160 different stars; so that the mean number of observations for each star is 1·44. The stars are arranged in order of R.A. The magnitudes are also given, the adopted scale being, as

nearly as possible, that of the *Uranometria Argentina*, which does not differ much from Argelander's. The zone observations were commenced in September 1872, and not finally completed (including a revision of all doubtful observations) until June 1883. The observations were made with a Repsold Meridian-Circle, the aperture of the object-glass being 121·9 mm., and its focal length 1·463 metres. The diameter of the graduated circle is 716 mm., and it is read by four microscopes. In the zone observations (in which two persons were simultaneously employed) it has been usual to take the transits of stars over three threads, and to read the circle by one microscope only, the difference between this reading and that of the mean of the four microscopes having been determined every day. The very creditable accordance of the separate observations is shown by a discussion of the results for stars which have been observed more than twice, from which it appears that the average discordance in Right Ascension is $0^s \cdot 062$ expressed in equatorial time; and the corresponding quantity in Declination is $0'' \cdot 972$. The *Cordoba Zone-Catalogue*, therefore, contains a very complete and accurate survey of the southern heavens, within the limits of declination mentioned above, down to magnitude 9½ (containing also many stars of the 10th magnitude); and although it has cost Dr. Gould some thirteen years of assiduous toil, still it will doubtless be sufficient recompense to him, on his return home, to feel that he has rendered great service to astronomy during his sojourn at Cordoba, not only by the publication of his zone-catalogue, but also by his *Uranometria Argentina* (already published), and by his General Catalogue of Southern Stars, which he intends to bring with him for publication in the northern hemisphere.

A. M. W. D.

The Glasgow Catalogue of Stars.

The astronomical history of the Glasgow University Observatory may be said to begin with the acceptance of the directorship in 1859, by Professor Grant. Finding it furnished with a Meridian-Circle, by Ertel & Sons, of Munich, of six French inches aperture, his first idea was to re-observe a certain number of stars, selected from the British Association Catalogue, but he soon enlarged his field of work, and set himself the stupendous task of carefully re-observing some 6,000 telescopic stars, selected from the first volume of Weisse's Bessel, and, therefore, within 15° of the Equator. Although having but one assistant, who, moreover, was frequently changed during the progress of the work, this object was steadily kept in view; and the volume before us, the first separate work issued from the Observatory, is the result of the patience and perseverance with which it was prosecuted.

The volume is prefaced with a short history of the Observa-

tory; then follows the introduction to the Catalogue, describing the principal instrument and methods of observing in all detail necessary for an opinion to be formed of the quality of the work.

As it formed no part of Professor Grant's project to determine absolute Right Ascensions—indeed, he states that in the climate of Glasgow the determination of the Azimuth constant, by upper and lower culminations, to be rarely possible—the Right Ascensions of the clock stars, as given in successive volumes of the *Nautical Almanac*, from 1861 to 1881, have supplied the fundamental Right Ascensions of the Catalogue.

The Greenwich first 7-year Catalogue for 1860 was used for the *Nautical Almanac* places of clock stars from 1871 to 1879, both inclusive; and as the greater part of the observations were made during these nine years, "the Right Ascensions of the Glasgow Catalogue may, therefore, be said to be mainly based upon the equinox of the Greenwich Catalogue for 1860."

To illustrate the annual variation of the instrumental constants, the level, collimation and Azimuth errors are given in full for the year 1866. The daily rate of the transit clock is given for 1867.

The North Polar Distances, which have been derived in an unusual manner, form a feature of the catalogue deserving (and requiring) close attention. The errors of division of the circle were determined in the usual manner for every 5°, and the error for each degree was inferred from an interpolating curve based upon the 5° errors. The observed Nadir point is given for 1861, 1870, and 1879, and the correction for runs of the screws of the microscope micrometers for 1866.

The peculiarity of the method of determining the North Polar Distances are best described in Professor Grant's own words:—

"The collimators which had been mounted in 1842 were found to be unfit for use. A comparison of the North Polar Distances observed during the period 1860–64 with the corresponding places of the Greenwich 7-year Catalogue for 1860, showed very satisfactorily that the systematic errors of the Glasgow observations, whether arising from flexure or any other unrecognised source, must be small. On the other hand, a comparison of the observations made subsequently to 1864 with the Greenwich Catalogue exhibited a pronounced residual difference depending on the zenith distance of the star. I am inclined to attribute this circumstance to a change in the flexure of the telescope tube occasioned by the introduction of the new eyepiece, observations with which were commenced in January 1865. I therefore decided upon determining the final correction to the North Polar Distances of the General Catalogue by means of the North Polar Distances of Stars observed during the period 1860–64. In pursuance of this view I formed a preliminary catalogue of the North Polar Distances of thirty stars based exclusively upon observations made during the period referred to. These results I then employed in the preparation of a definitive or

standard catalogue resting upon a broader basis of observation, a catalogue of the North Polar Distances of 116 stars derived from the observations made at the Glasgow Observatory during the twelve years extending from 1860 to 1871, and including the stars contained in the preliminary catalogue. . . . .

"The next step was to derive from the North Polar Distances of the preliminary catalogue a correction to the North Polar Distances of the larger catalogue of 116 stars. It has been already stated that the thirty stars of the preliminary catalogue were included in the larger catalogue here referred to. A comparison of the corresponding North Polar Distances of the two catalogues arranged in the order of magnitude of North Polar Distance, gave, for the correction applicable to the thirty North Polar Distances of the larger catalogue, the expression—$1''\cdot 28 \sin z$, z denoting the zenith distance of the star."

A comparison between the North Polar Distances of the preliminary catalogue and the North Polar Distances of the same stars in the larger catalogue, corrected as above, warranted the application of the same correction to all the other stars of the larger catalogue. Accordingly this was done, and the final North Polar Distances were obtained of the larger catalogue, which was henceforth assumed as the standard catalogue by means of which was determined, in every instance, the final corrections to the observed North Polar Distances of the General Catalogue. The method of obtaining the correction in a given case is explained at length, and both the preliminary and the larger catalogue of North Polar Distances are given, with abundant illustration of the application of this final correction.

The value of the catalogue is greatly enhanced by the publication of the Star Ledger, which indeed forms the bulk of the volume. Means are thus supplied for correcting any catalogue place of the star for equinox or proper motion.

The catalogue not only supplies much more accurate places than those at present available of a large proportion of Bessel's Stars, which observers (and still more calculators) of comets and minor planets will duly appreciate, but the places have that accuracy, certainly in Right Ascension, which fits them for investigations of proper motion. Professor Grant has in fact investigated the proper motions of ninety-seven of his stars which were common to Lalande and Bessel.

The proper motions of Bradley's Stars have not been generally applied to the Glasgow Catalogue places. A comparison between the Glasgow places and the places in the Greenwich 9-year Catalogue for 1872 (the epoch of the Glasgow Catalogue is 1870) of the first fifty stars common to both catalogues shows a very close agreement in Right Ascension, a difference of $0^s\cdot 1$ being rare. Differences in N.P.D. of $2''$ are not uncommon (six of the fifty ranging between $1''\cdot 5$ and $2''\cdot 5$); but this, perhaps, is no more than should be expected. A very large number of Schjellerup's Stars are found in the catalogue, the limits of N.P.D. being practically the same.

The catalogue has been discussed by Dr. A. Auwers in *Vierteljahrsschrift der Astr. Gesellsch.*, Jahrg. XIX. Heft 3.

The volume is carefully printed, and in an exceptionally handsome manner, by H.M. Government on the recommendation of the Committee of the Royal Society.*

Dr. Backlund's Investigation of the Motion of Encke's Comet.

Dr. Backlund, of Pulkowa, has published in the *Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg*, tome xxxii., the results of an important investigation on the motion of Encke's Comet during the years 1871–1881, in which he not only removes some doubts which are left unexplained in Von Asten's classical memoir on the subject, but materially advances the theory of the Comet. It will be remembered that the researches of Von Asten, while completely establishing the fact of the acceleration of the mean motion, and confirming the amount previously derived by Encke, nevertheless indicated that the observations, made subsequently to 1865, could be represented by a purely gravitational theory. This apparent discontinuity in the law is shown by Dr. Backlund to have its origin in the employment of erroneous formulæ for the computation of the perturbations of the second order for the period 1865–1868. Owing to the approach of the Comet to *Jupiter* in that revolution, these perturbations are considerable, and the error thus introduced, though not yet definitely determined, amounts approximately to 18″ in the mean anomaly, and to $+0''\cdot06$ in the mean motion.

In addition to the removal of this perplexing difficulty, Dr. Backlund introduces a greater delicacy into his calculations by substituting a more accurate method of computing the mean anomaly. In Von Asten's calculations the alteration in the mean motion produced by the so-called "resisting medium" is made *per saltum* at the moment the Comet passes through perihelion. Dr. Backlund prefers to apply this correction (as also the consequent increment to the eccentricity) in proportion to the time, and further considers the effect of a periodic term, hitherto neglected, but which is a necessary consequence of the original hypothesis. On the assumption that the acceleration (μ') is $0''\cdot104$, this periodic term becomes $-8''\cdot15 \cos 2u$, where $2u$ is an angle depending on the true anomaly, and may vary 40° or 50° in an apparition. This term, therefore, is clearly not negligible, and the small corrections to planetary masses, &c., which have been inferred from the discussion of the motion of this Comet, in which this term has not been considered, are subject to a proportionate degree of uncertainty.

* The following misprints were noticed: No. 168 proper motion in R.A. should be $-\cdot018$. No. 340 is μ *Piscium* not ω. No. 249 is Piazzi 246.

The final comparison of the theoretical positions with the normal places (17 in number) is made on three assumptions—1, neglecting this periodical term; 2, retaining it; and 3, with the periodic term still retained but the Bessel-Schur mass of *Jupiter* substituted for the value derived by Von Asten from the discussion of the motion of this Comet. The principal results can be best seen from an inspection of the following table:—

	Correction to Daily Motion.	Consequent Corr. to Eccentricity.	Value of Periodic Term.	Prob. Error of Normal Place.
	$''$	$''$	$''$	$''$
Hypothesis I.	$+0''.045982$	$-1''.61$		$\pm 5''.005$
„ II.	$+.04575$	-1.61	-3.54	± 4.161
„ III.	$+.054000$	-1.90	-4.20	± 2.777

The smallness of the probable error of a normal place in the third hypothesis is remarkable, when all the causes that contribute to augment it are considered; and there can be no doubt that the conclusion of a gradual diminution in the acceleration drawn from an inquiry so rigorously conducted in its methods, and so satisfactory in its results, is entitled to very great weight.

This gradual diminution, although its explanation is not easy to conjecture, is best shown by quoting the various values that have been assigned to it, with their probable errors.

1819–65	... ...	$\mu' = +0''.104418 \pm 0.0001353$
1865–71	... ...	$\mu' > +0.06 < +0.10$
1871–81	... ...	$\mu' = +0.054000 \pm 0.0005244$

Dr. Backlund concludes his paper by some theoretical considerations of the law by which the resisting medium might operate. The hypothesis has hitherto been exclusively confined to that case in which the accelerating force is supposed to act directly as the square of the velocity, and inversely as the square of the distance. Dr. Backlund considers the effect on the path of the Comet of a force acting proportionally to any positive power of the velocity and any negative power of the distance, and gives rigorous formulæ for the variations of the mean motion, eccentricity, (ϕ') longitude of the perihelion, and the mean anomaly. The effect on the longitude of the perihelion is shown to consist entirely of periodic terms, and of so small an amount that their detection by observation is impossible; but since Von Asten determined directly from the observations the variation of the eccentricity, a comparison between his result and the theoretical value is possible, and it might have been anticipated that some confirmation of, or alteration in, the law as originally imagined by Encke could be effected. Von Asten's determination of ϕ' is, however, accompanied by a probable error of such an amount

as to prevent any trustworthy deduction in this direction; and the only certain conclusion to be drawn from the comparison is, that there is no ground for preferring Encke's hypothesis to any other which, while preserving the ratio between μ' and ϕ', offers additional computational advantages. W. E. P.

Dembowski's Double Star Measures.

A very valuable addition to observational Astronomy has been made by the publication in two volumes of Baron Dembowski's micrometric measurements of double stars. Those who have had to hunt through scattered numbers of the *Astronomische Nachrichten* for observations will much appreciate this work.

Vol. I. contains a short biographical notice of the author by MM. Otto Struve, and G. V. Schiaparelli, in which they bear testimony to the admirable perseverance of Dembowski, who in the seventeen years from 1862 to 1878 made many thousands of measures of double stars; and when it is remembered that he was then (1862) fifty years of age, it will always be a satisfaction that his merit was recognised by the reward of the medal before his death.

This volume contains six groups of measures, these being (1) a long series of re-measurement of stars taken from Struve's *Mensuræ Micrometricæ*; (2) re-measurement of over 400 stars from Otto Struve's catalogue; (3) a series of measures of stars whose distance is between 32″ and 120″; (4) a series of measures of double stars whose duplicity was discovered by Mr. Burnham; (5) a series of measures of double stars discovered by Herschel, I. and II., Dawes, Alvan Clark, Schjellerup, and Dembowski, and finally a set of observations of 26 circumpolar stars. It would have been more convenient if the approximate places in both elements (say to the nearest minute) had been printed on a line with the star's name and Struve's number, instead of being placed in an appendix.

Vol. II. contains an introduction, which is divided into ten chapters, and treats of the telescope, the mode of observation, the value of micrometer revolutions, &c., and the whole of these chapters are worthy of study, showing as they do the care taken by Dembowski in clearing his observations of instrumental errors. Details are then given of his methods for determining the probable errors of single observations, which show that in the closer stars his results agree very well with Struve's, as given in the *Mensuræ Micrometricæ*.

The great attention paid to some of the short period binary stars may be inferred when it is stated that no less than 120 sets of measures were made of η *Cassiopeiæ* between 1862 and 1878; 44 of 36 *Andromedæ*, of ζ *Cancri* 126, and on most occa-

sions the stars were seen divided sufficiently to *estimate* distance, and from 1874 to 1878 *measures* of distance were obtained with a power of 500.

ξ *Ursæ Maj.* was observed on 134 nights, and measured from a position angle of 99°, through its retrograde motion to an angle of 284°.

γ *Virginis*, ξ *Boötis*, η *Coronæ* (the distance of which has, in nearly every instance, been *measured*), ξ *Libræ*, λ *Ophiuchi*, ζ *Herculis*, τ *Ophiuchi*, 70 *Ophiuchi*, δ *Cygni*, have all received an extraordinary amount of attention.

An appendix is given showing the correction for refraction to be applied to stars of the Dorpat Catalogue, whose distances exceed 32″.

Dunsink Parallax Researches.

In Part V. of the Dunsink Observations Dr. Ball publishes the second instalment of his researches on stellar parallax. Part III. (1879) contained his observations of forty-two stars which showed that no one of them had a large annual parallax. The present volume contains the observations of no less than 368 objects, not one of which rewarded the indefatigable observer by indicating a parallax large enough to be detected by the methods employed.

The volume also contains "Further Researches on the Annual Parallax of 61 *Cygni*," by differences of declination measured in 1878–79 on thirty-seven nights, with the result—

$$+0''.47 \pm 0''.03.$$

Also special investigations of the parallaxes of *Groombridge* 1618, *Piazzi* III. 242, and 6 *Cygni*, with the following results:—

Groombridge 1618, from observations on 106 nights in 1878–80, annual parallax—

$$+0''.32 \pm 0''.02.$$

Piazzi III. 242, from observations on thirty-one nights in 1879, annual parallax—

$$-0''.04 \pm 0''.07,$$

which indicates that the difference between the parallaxes of the two stars compared is too small to be measured.

6 *Cygni*, from observations on thirty-seven nights in 1880–81, annual parallax—

$$+0''.48 \pm 0''.05.$$

Professor Pickering's Observations with the Meridian Photometer during the Years 1879–82.

This publication, in several points of view, presents remarkable and interesting features. For centuries past the apparent comparative lustre of the stars has engaged the attention of astronomers from Ptolemy downwards, and many of them have left records of the result of their labours given in well-known catalogues. These, however, were but estimations of comparative brightness made with greater or less success by the unaided eye. There have also been a few very valuable, but somewhat spasmodic, attempts made to apply various forms of photometric measures, claiming an exactness belonging to a higher order of scientific merit.* In the volume before us we have the first record of a systematic investigation of "star magnitudes" made with a photometer contrived on unimpeachable principles, and extended to all stars recorded in the catalogue of Argelander's "Uranometria Nova," with the addition of some others, down to the sixth magnitude and above the parallel of 30° South Declination. It is true that this Harvard Catalogue has been anticipated by the publication of a regular series of photometric observations made at Oxford, with a very different but probably equally reliable instrument, but the latter research, so far as at present published, extends only so far as stars ranging between the first and the fourth or fifth magnitudes.

The volume containing these observations consists of 324 closely printed pages, embracing a mass of print which of itself excites the attention of the reader. It is divided into six chapters. The first of these contains a description of the photometer employed. It is an ingenious adaptation of various expedients devised by successive astronomers, from Sir J. Herschel down to the present time, but possessing features of its own, which may fairly establish its claim to be regarded as an original instrument. The general principles of the construction and use of the instrument seem fairly clear. Two similar telescopes, each having an object-glass of about one and a half inch aperture and thirty inches focal length, with a power of fifteen linear, are placed horizontally in juxtaposition. On each of the object-glasses is a rectangular prism, by the motion of which it is mechanically contrived that the images of *Polaris* and of any star in or very near the meridian can be formed in the focus of each telescope, and so viewed in juxtaposition by means of one eye-piece. Before these images are formed, the pencils from the two stars pass through an optical arrangement of double refraction, so arranged that by gradually rotating a Nicol prism the two polarised images may be equalised, and in this way, by means with which physicists

* For the history of these researches, see *Memoirs, Roy. Astr. Soc.*, vol. xlvii. p. 367.

are familiar, it is possible to measure the relative brightness or magnitudes of *Polaris* and the star in question. Two persons are necessary for the observation. The one moves one of the prisms so as to place the image of the meridian star in the field of view, while the observer, properly so called, has the command of *Polaris*, and he also turns the Nicol prism until the two images are equalised. The position of the Nicol is read and recorded by the assistant, whose eye is not before the telescope. The observer then reverses the images of the two stars, right and left, by moving the *Polaris* prism, and then the operation of equalisation is repeated. We do not doubt that this principle of reversing the images was necessary, as it is stated that it was ultimately found to be, in order to secure the precision of the measures, but we are greatly disposed to doubt whether the necessity of this operation does not arise from other contributory causes than those assigned in the volume—viz. from the fact that the human eye may be greatly biased in its estimate of the relative intensity of two lights in juxtaposition, by their mere relative position of right and left. These operations of setting, equalising, reading, reversing, &c., are performed with such rapidity, that we believe the average number of complete observations does not fall below forty per hour. The necessity for these extremely rapid observations appears to arise chiefly from the construction of the instrument, there being, so far as we can gather, no automatic contrivance provided for the motion of the instrument to follow the southern star; the many and serious discordances recorded in the individual measures may, we think, be attributed partly to this rapidity, and, it may be presumed, the accuracy of the resulting mean is affected thereby. Nevertheless we cannot overlook the judgment and ability of Professor Pickering in devising the method before us, and the effect of the discordances of the individual measures may, in some cases at least, possibly be obviated by the number of the observations.

Chapter II. is chiefly occupied in giving a summary of the whole operations, and in discussing the conventional magnitude of *Polaris*, which was found from observations to be practically invariable during the three years occupied by the work, viz. from October 1879 to September 1882.

Chapter III. is occupied by the atmospheric absorption of light emanating from the stars. The coefficient of absorption finally adopted is ·25 of a magnitude on Pogson's scale. This coefficient, though coinciding exactly with that determined at Oxford, is greater than that determined at several places on the Continent of Europe, and seems to imply a somewhat vaporous atmosphere at Harvard. A peculiarity in the method of these observations consists in the fact that they were necessarily made on stars viewed in the same azimuth, viz. due north. This we are disposed to regard as liable to objection, inasmuch as the absorption corrections are for the most part to be made to stars observed in the contrary direction, viz. due south where

the meteorological and topical circumstances may be very different. A very far more serious objection is that the same coefficient is applied on all nights, wherein the meteorological conditions greatly vary, and the coefficient is very seriously affected thereby. Whether or not this difficulty is removed by the multiplication of the observations it is not easy to see, but individual observations must be seriously affected, and of these we think we see decided traces. If in photometrical work the utmost attainable accuracy is not secured, it is difficult to see where it is superior to ordinary estimations by the unaided eye. In many questions it is important to discriminate between the mean and the actual brightness of a star at a particular epoch.

In the fourth chapter are given the results of eye estimations of the brightness of most of the stars photometrically measured. Professor Pickering says that "it is obviously desirable that photometric determinations of the light of stars should be compared with similar results obtained by the direct estimation of relative brightness." Granting this, it seems obviously still more desirable that where the photometric and the direct observations disagree, the cause should be at once searched into, and, if possible, eliminated. For it is impossible to overlook the fact that in a very great many instances there are recorded in the Harvard volume serious differences between the photometric and the direct observations, amounting sometimes to as much as half a magnitude, and occasionally even larger discrepancies are observable. There seems but one conclusion to be drawn from a fact of this nature: either the photometer or the eye is in error; and it is worthy of remark that the individual deviations of the eye estimations are not perceptibly much more discordant than are those of the recorded photometric measures. It seems probable, notwithstanding these and other advances in stellar photometry, that we have not as yet anywhere arrived at a degree of precision which can properly be regarded as final.

In the fifth chapter are given the main results of the entire investigation. It is impossible not to be struck with the immense amount of labour and indefatigable zeal to which every page in this chapter bears witness. It contains the records of the results of an immense undertaking even for the eight or nine observers employed therein during the space of three years. The pages of this chapter are a model of condensation, and afford in a brief space an enormous amount of information of the processes involved in the actual observations, and of the results of many previous observers.

With one or two final remarks we shall conclude our rapid summary of the contents of this remarkable volume. There are given the results of no less than fourteen sets of eye estimations of stellar lustre made by various antecedent astronomers. The resulting magnitudes are said to be reduced to an uniform scale. This we should have regarded as not possible, having regard to scientific accuracy. In estimates made by the unaided eye, an

uniform numerical scale, reaching from the brightest to the faintest star, seems impossible, and beyond all doubt no such scale exists when examined by the aid of photometric results.

The records of a great, difficult, and original work, such as the one before us, containing, as it does, an enormous amount of unavoidable detail, and executed in so brief a time, must contain a few blemishes, more or less; and if we have indicated some instances which appear open to criticism, it is not inconsistent with a hearty participation in the admiration which is deservedly entertained by practical astronomers for this very important addition to the science which this volume undoubtedly extends.

C. P.

Dr. Huggins's Method of Photographing the Solar Corona without an Eclipse.

At the anniversary meeting of the Royal Society the Treasurer, Dr. Evans, made the following statement:—

"In his address last year the President called attention to the discovery by Dr. Huggins of a method of photographing the Solar Corona without an eclipse; and for the purpose of making further experiments in this direction, and for carrying on other physical observations at some place of high elevation and of easy access, a grant of 250*l.* was placed at the disposal of a committee. The place of observation selected by the committee was the Riffel, near Zermatt, in Switzerland, which has an elevation of 8,500 feet, and possesses important advantages both of access and of hotel accommodation. They appointed Mr. C. Ray Woods, who had had experience in photographing the Corona during the eclipse of 1882 in Egypt, and again in Caroline Island in 1883, to take charge of the work under the instructions of Dr. Huggins and Captain Abney.

"Mr. Woods arrived at the Riffel in the beginning of July, when he erected the necessary instruments under a tent of 'Willesdenised' paper, and continued at work there until September 21. Unfortunately, the present year has been exceptionally unfavourable for work on the Corona, in consequence of an unusual want of transparency in the higher regions of the atmosphere. This probably may be owing to the presence there of ice crystals or of small particles of matter of some kind, such as, personally I am tempted to think, might be due to the Krakatoa eruption. Whatever the cause, the sky as seen from the Riffel was far from being so clear as it has been during former years. Mr. Woods observed that the freer the lower air was from cloud and mist, the more distinctly came out a great aureola around the Sun; which he found to have a diameter of about 44°, and to be of a faint red near the outer boundary, and bluish-white within, up to the Sun's limb.

"These unfavourable conditions of the atmosphere have made it impossible for Dr. Huggins to obtain any photographs of the Corona in England. The great advantage at the Riffel of being free from the light scattered from the lower eight thousand feet of air has enabled Mr. Woods, notwithstanding the serious drawback of the persistent aureola, to obtain about one hundred and fifty photographs, of which more than half are sufficiently good to show the general form of the Corona, and a smaller number the stronger details of that part of the Corona which lies within from 8′ to 12′ of the Sun's limb. It would be premature to express any opinion as to the information which may eventually come out from the Riffel plates. They are now being drawn preparatory to a full discussion. In the meantime I may congratulate the Society upon the confirmation of the hope expressed by our President at the last anniversary that 'a new and powerful method of investigation has been placed in the hands of students of Solar Physics.'"

By the aid of a special grant from the Government fund, Dr. Gill is going to take a series of daily photographs of the Solar Corona, as part of the regular work of the Cape Observatory, for the carrying out of which he has engaged Mr. Woods as assistant.

Professor Langley on the Amount of the Atmospheric Absorption.

The results of his various investigations on Solar Radiations have led Professor Langley to a conclusion, as to the amount of the absorption exercised by our atmosphere, most strikingly at variance with the views generally held. He communicated a paper on the subject to the National Academy of Sciences in April 1884, and has since reproduced its substance in an article which appeared in the *American Journal of Science* for September 1884. The point upon which his argument turns is, that up to the present time it has been almost universally assumed in the reduction of observations that the coefficient of transmission is a constant, an assumption involving the further one, that the solar radiations are either perfectly homogeneous, or suffer absorption as if they were. But we now know that they are of an infinite degree of complexity, and that they are affected in very diverse degrees by their passage through our atmosphere.

It is clear, therefore, that the usual exponential formula, $Ap^{\epsilon}=t$, is inexact, and Professor Langley has no difficulty in showing by a simple algebraical treatment of a case in which the radiations are supposed to be of two kinds only, that it is erroneous always in the same direction, since it always makes the coefficient of transmission too large, and always larger and larger as the horizon is approached. The amount of the error is not, however, indicated, and since the value of the coefficient of transmission, as found by a number of observers from many

thousands of observations over a wide range of zenith distances of the Sun has been practically, always the same, it might be urged that it could not be very great. To this objection Professor Langley replies by showing that the error will increase with the difference between the coefficients proper to the various individual radiations, so that "however close the agreement may be between observations on absorption made at quite different altitudes of the heavenly body, we have no right to infer that the error of the final result is not indefinitely great." It is obvious that the error will be very serious if the coefficients for a large number of radiations approach zero; and Professor Langley points out that the presence in the spectrum of strongly marked telluric lines, even in observations made at great elevations above the sea, is evidence of coefficients of transmission for those particular rays, which must be small indeed. He then takes an imaginary instance in which the radiant energy before absorption is supposed to be divided into ten parts, each with its own coefficient of transmission, and he chooses values for these so as to represent as nearly as practicable the observed facts of nature. Reducing by the ordinary method the values observed after one, two, three, and four absorptions, he shows that the values of the atmospheric absorption which would be obtained would be 21, 19, and 18 per cent.; whereas the actual absorption would have been 41 per cent., or more than double the mean of the three separate determinations, although these accorded with each other very fairly.

To obtain a truer view than we have at present of the loss by atmospheric absorption, we are only able to divide the spectrum into a finite number of parts and to sum the results. This Professor Langley has already achieved to a considerable extent by means of his Bolometer, though even with this instrument, as he is careful to note, we are far from dealing with truly homogeneous rays, and we can only regard the error as lessened, not as removed. Professor Langley, by his observations on the summit and at the foot of high mountains, avoided some of the sources of error incident to the ordinary method of observing a high and low Sun, and he recommends the further development of his method when practicable. But he also suggests a third method more generally applicable—viz., the comparison of the heat and light from the sky around the Sun with that from the whole sky apart from the Sun, since it is clear that the whole of the light reflected to us from a pure and uniform sky—on the average he estimates, as much as we receive directly from the Sun—represents so much loss in the direct transmission. Professor Langley concludes by asserting his belief, which seems well supported by the evidence he has adduced, that the mean absorption of light and heat by our atmosphere is, in all probability, *at least double* that at which it is customarily estimated, and that fine dust particles play a more important part in this absorption than has been heretofore supposed.

It should be added that although stellar radiations must suffer loss in the same general proportions as solar, yet, that since our determinations of stellar magnitudes are relative only, these will be but little affected, except in the case of stars of pronounced colour, by the error of the formula usually adopted for atmospheric absorption. E. W. M.

The International Meridian Conference.

On the invitation of the President of the United States a conference of delegates from twenty-seven States met at Washington on October 1, under the presidency of Admiral Rodgers, U.S.N., to fix on a meridian proper to be employed as a common zero of longitude and standard of time-reckoning throughout the world. After a full discussion the following resolutions were adopted:—

I. "That it is the opinion of this Conference that it is desirable to adopt a single prime meridian for all nations, in place of the multiplicity of initial meridians which now exist."

This resolution was adopted unanimously.

II. "That the Conference proposes to the Governments here represented the adoption of the meridian passing through the centre of the transit instrument at the Observatory of Greenwich as the initial meridian for longitude."

This resolution was adopted by the following vote:—

In the affirmative—

Austria-Hungary	Mexico
Chili	Netherlands
Colombia	Paraguay
Costa Rica	Russia
Germany	Salvador
Great Britain	Spain
Guatemala	Sweden
Hawaii	Switzerland
Italy	Turkey
Japan	United States
Liberia	Venezuela

In the negative—

San Domingo.

Abstaining from voting—

Brazil	France

Ayes, 22; noes, 1; abstaining 2.

III. "That from this meridian longitude shall be counted in two directions up to 180 degrees, east longitude being plus and west longitude minus."

This resolution was adopted by the following vote:—

In the affirmative—

Chili
Colombia
Costa Rica
Great Britain
Guatemala
Hawaii
Japan
Liberia
Mexico
Paraguay
Russia
Salvador
United States
Venczuela

In the negative—

Italy
Netherlands
Spain
Sweden
Switzerland

Abstaining from voting—

Austria-Hungary
Brazil
France
Germany
San Domingo
Turkey

Ayes, 14; noes, 5; abstaining 6.

IV. "That the Conference proposes the adoption of a universal day for all purposes for which it may be found convenient, and which shall not interfere with the use of local or other standard time where desirable."

This resolution was adopted by the following vote:—

In the affirmative—

Austria-Hungary
Brazil
Chili
Colombia
Costa Rica
France
Great Britain
Guatemala
Hawaii
Italy
Japan
Liberia
Mexico
Netherlands
Paraguay
Russia
Salvador
Spain
Sweden
Switzerland
Turkey
United States
Venezuela

Abstaining from voting—

Germany
San Domingo

Ayes, 23; abstaining, 2.

V. "That this universal day is to be a mean solar day; is to begin for all the world at mean midnight of the initial meridian,

coinciding with the beginning of the civil day and date of that meridian; and is to be counted from zero up to twenty-four hours."

This resolution was adopted by the following vote:—

In the affirmative—

Brazil	Japan
Chili	Liberia
Colombia	Mexico
Costa Rica	Paraguay
Great Britain	Russia
Guatemala	United States
Hawaii	Venezuela

In the negative—

Austria-Hungary	Turkey
Spain	

Abstaining from voting—

France	San Domingo
Germany	Sweden
Italy	Switzerland
Netherlands	

Ayes, 14; noes, 3; abstaining 7.

VI. "That the Conference expresses the hope that as soon as may be practicable the astronomical and nautical days will be arranged everywhere to begin at mean midnight."

This resolution was carried without a division.

VII. "That the Conference expresses the hope that the technical studies designed to regulate and extend the application of the decimal system to the division of angular space and of time shall be resumed, so as to permit the extension of this application to all cases in which it presents real advantages."

This resolution was adopted by the following vote:—

In the affirmative—

Austria-Hungary	Mexico
Brazil	Netherlands
Chili	Paraguay
Colombia	Russia
Costa Rica	San Domingo
France	Spain
Great Britain	Switzerland
Hawaii	Turkey
Italy	United States
Japan	Venezuela
Liberia	

Abstaining from voting—

Germany. Sweden.
Guatemala.

Ayes, 21; abstaining, 3.

These resolutions, which were proposed by Mr. Rutherford (one of the delegates of the United States), differ from the recommendations of the meeting of the Geodetic Association at Rome, in October 1883, in two important points: (1) That the practice of reckoning longitude from 0° to 180° east and west of the initial meridian is to be retained, the proposal to count in one direction only from 0° to 360°, which was adopted at Rome, being rejected at Washington. (2) That the universal day should begin at Greenwich mean midnight (coinciding with the civil day) instead of beginning at Greenwich mean noon (coinciding with the astronomical day) as recommended at Rome.

As regards (1), the proposition to count longitude from 0° to 360° eastward, which was adopted without discussion by the Geodetic Association (composed of European astronomers and geodesists), met with strong opposition from the representatives of the various States of North and South America, who considered that the proper direction in which to count longitude was westward, and it became evident that no agreement could be expected as to the direction to be adopted. Under these circumstances it was considered preferable to retain the existing practice of geographers and navigators, and Professor Adams pointed out that there was no difference of principle between the practice of counting in one direction only, or in two opposite directions, considering longitudes measured in one direction as positive and in the other direction as negative. In the former case, however, there would be discontinuity in passing from 360° to 0° at the prime meridian, which passes through densely populated countries, whilst in the latter the discontinuity would occur in passing from +180° to −180°, viz. in mid-ocean, where it would cause very little inconvenience, and where ships are now in the habit of making the change of date.

The proposal to reckon universal time from noon of the initial meridian, which was carried by a majority at Rome, was strongly opposed at Washington by the delegates from the United States, Russia, and Great Britain, the feeling expressed being that the transition from local or other standard time in ordinary use to universal time should be as easy as possible, whilst the view of the Committee of the Geodetic Association, which proposed noon as the starting-point, was that local time should not be in any way related to universal time, and that the latter should be used only for the internal service of railways and telegraphs. According to this scheme universal and local time would be kept as distinct as possible, the hours of the former being counted from 0 to 24, starting with noon, and of the latter from 0 to 12 A.M. and

P.M. At Washington, on the other hand, M. de Struve, on behalf of the delegates from Russia, considered it desirable that both universal and local time should be reckoned from 0^h to 24^h, and that the former should start with midnight of the initial meridian, so that for nearly the whole of the inhabited parts of the world the difference of date between local and universal time would not fall during the principal business hours of the day. Mr. W. F. Allen, Secretary of the Railway Time Convention of the United States and Canada, argued from the experience of Great Britain, Sweden, the United States, and Canada, that standard time, differing by an exact number of hours from universal time, could practically be adopted all over the world, and that therefore it was not necessary, as had been maintained at Rome, to retain exact local time side by side with universal time. He stated that the new standards of time 5^h, 6^h, 7^h, and 8^h slow on Greenwich, had been already adopted by nearly 85 per cent. of the total number of cities of over ten thousand inhabitants in the United States, and that it was used on 120,000 miles of railway in the United States and Canada, being 97½ per cent. of the total mileage. As affecting astronomers and navigators, both Professor Adams and Commander Sampson, U.S.N., preferred to commence the universal day at midnight, as proposed by Mr. Rutherford, and in this view they were supported by Professor W. Valentiner and Professor Hilgard. Admiral Rodgers, U.S.N., the President of the Conference, added that it was already the practice in the U.S. Navy to reckon the day from midnight.

In explanation of the circumstance that the delegates of many of the European States abstained from voting on Nos. III. and V. of the Washington resolutions, it is to be remarked that Austria-Hungary, Germany, Italy, Netherlands, Spain, Sweden, and Switzerland were only represented by diplomatists, who were understood to have received instructions from their respective Governments simply to vote for the recommendations of the Geodetic Conference at Rome.

The British delegates at Washington were Professor J. C. Adams; Captain Sir F. J. O. Evans, R.N.; Lieut.-Gen. Strachey, R.E. (representing India); and Mr. Sandford Fleming (representing Canada).

Telegraphic Longitudes in Australia and New Zealand.

It had formed part of the programme of the Transit of *Venus* 1882 Expeditions to Australia that the longitudes of the principal Observatories on that continent should be determined, taking as a starting-point the station at Singapore, which was connected with Madras in 1870 by Professor Oudemans. Early in 1883 Captain Darwin, R.E., proceeded to Singapore with a transit instrument and clock. At the same time Mr. Baracchi,

an assistant at the Melbourne Observatory, went to Port Darwin similarly equipped. Both these gentlemen had previously compared their mode of observing with the principal observers at Adelaide and Melbourne, and Captain Darwin at Sydney also.

Signals were successfully exchanged through the cables between Singapore and Port Darwin, and between Port Darwin and the Observatories of Adelaide and Melbourne independently through an immense length of land line. The details of the various operations have not yet been published, but the very approximate results are known.*

In the same year the longitude of the Survey Observatory, Mount Cook, Wellington, New Zealand, was determined by Mr. Russell at Sydney and Mr. Adams at Wellington, the latter gentleman, acting under the direction of the surveyor-general of New Zealand, having first visited Sydney in order to compare himself, in observing transits, with the observers there. The whole of Mr. Adams' careful observations for local time are published in detail,† and it is much to be regretted that no information of a similar kind is supplied from Sydney Observatory.

The following are the results of these operations, the longitudes being all east of the Royal Observatory, Greenwich :—

	h	m	s
Starting Point, Flagstaff, Government Hill, Singapore, Professor Oudemans' in 1870	6	55	22·71
Port Darwin (Baracchi's Station)	8	43	21·74
Adelaide Observatory	9	14	19·61
Melbourne Observatory	9	39	53·38
Sydney Observatory	10	4	48·47
Mount Cook Observatory, Wellington	11	39	5·46

* Mr. Charles Todd in *Observatory*, 1883 October; also "Report of Surveyor-General of New Zealand," 1883–84.

† *Loc. cit.*

Papers read before the Society from February 1884 to February 1885.

1884.

Mar. 14. Variation in the light of *Neptune*. Maxwell Hall.

Note on Professor Adams's paper in the *Monthly Notices* for December 1883. E. J. Stone.

Additional note on the change of the unit of time. Professor A. Cayley.

Spectroscopic observations of Comet Pons-Brooks. Dr. N. de Konkoly.

Spectroscopic observations of the red-coloured sky at sunset. Dr. N. de Konkoly.

Electric illumination of spectroscope micrometers. Dr. N. de Konkoly.

On a new colorimeter, serving as a spectral photometer. R. de Kövesligethy.

Some remarks on the spectroscopic determination of the motions of Stars in the line of sight. R. de Kövesligethy.

Remarks on Major-General Tennant's paper "On the change in the adopted unit of time." Professor J. C. Adams.

A general law of Planetary and Cometary motion in the Solar System. Professor C. V. Zenger.

Observations of occultations of Stars by the Moon, and of phenomena of *Jupiter's* Satellites made at the Davidson Observatory, San Francisco, and at Table Mount Station, California. Geo. Davidson.

Remarks on Mr. Hilger's illumination of micrometers by vacuum tubes. Dr. N. de Konkoly.

Observations of Sun-spot spectra in 1883. Rev. S. J. Perry.

Phenomena of *Jupiter's* satellites observed at Stonyhurst in 1883. Rev. S. J. Perry.

Sextant observations of Pons's Comet. Capt. W. L. Rosseter.

Observations of Pons's Comet made at the United States Naval Observatory, Washington. W. T. Sampson and E. Frisby.

The new Comet of 1884 January 12. N. R. Pogson.

Observations of Comet *b* 1883 (Pons-Brooks), made at Vizagapatam. A. V. Nursingrow.

Questions respecting Mr. Stone's theory of a change in the mean Solar day. Professor S. Newcomb.

Remarks on the value of the secular acceleration of the Moon's motion derived from observation. Professor S. Newcomb.

On the necessary distinction in practical astronomy between the true mean Solar day and the mean day adopted, from time to time, in the construction of our Astronomical Tables, and in the comparison of these tables with observations. E. J. Stone.

Sextant observations of Comet *b* 1883 (Pons-Brooks), made at Monte Video. Rev. S. S. O. Morris.

Occultations observed at Forest Lodge, Maresfield. Capt. W. Noble.

Note on the Transit of the fourth Satellite of *Jupiter*, 1884 March 12. E. J. Spitta.

Note on the determination of the Planes of the Orbits of *Jupiter's* Satellites. A. Marth.

Remarques sur les "Notes on Nyrén's determination of the constant of aberration," de M. Gill. M. Nyrén.

Observations of the occultation of *Venus* by the Moon, made at the Royal Observatory, Greenwich, 1884 February 29. Communicated by the Astronomer Royal.

On an instance of change of personality in observing position-angles of Double Stars, and on the orbit of *α Centauri*. A. M. W. Downing.

Suggestions for improvements in the construction of large Transit Circles. A. A. Common.

The parallax of *α Tauri*. Professor O. Struve.

April 9. A method for clearing a lunar distance. J. Merrifield.

Notes on Nyrén's determination of the constant of aberration. David Gill.

Observations of Comet *a* 1884, made at Windsor, New South Wales. J. Tebbutt.

Some remarks on the chain of Meridian distances measured around the earth by H.M.S. "Beagle," between the years 1831 and 1836. Professor A. Auwers.

The radiant points of fireballs. W. F. Denning.

A new dark field micrometer, and electric illumination of Equatorial at Melbourne. R. L. J. Ellery.

Observations of Comet Ross, made at the Observatory, Melbourne. R. L. J. Ellery.

Occultations of *λ Geminorum* and *κ Cancri*. Henry Pratt.

Abnormal appearance of *Jupiter's* Satellite iv., while in Transit on March 12. Henry Pratt.

May 9. Elements of the Orbit of Comet *a* 1884. J. Tebbutt.

The Orbit of Pons's Comet. Dr. J. Morrison.

Observations made at the United States Naval Observatory, Washington. Professor A. Hall.

The motion of *Hyperion*. Professor A. Hall.

Sextant observations of Comet Pons-Brooks, made on board the ship "Earnock." Capt. G. F. Parson.

Observations of the companion of *Sirius*, made at the Dearborn Observatory, Chicago. Professor G. W. Hough and S. W. Burnham.

On the occultation of κ *Cancri*. Dr. C. L. Prince.

On the corrections required by Hansen's "Tables de la Lune." E. Neison.

Note on Dr. N. de Konkoly's remarks on Mr. Hilger's illumination of micrometers by vacuum tubes. Rev. S. J. Perry.

Note on the eclipse of Thales. J. Maguire.

Sextant observations of Comet Pons-Brooks, made on board the ship "Superb," January and February 1884. Capt. D. W. Barker.

Sextant observations of Comet Pons-Brooks, January 1884. Capt. A. S. Thomson.

On the proper motions of forty Stars in the Pleiades, both absolute and relative. Professor Pritchard.

Observations of *Mars* at the opposition of 1884. E. B. Knobel.

Suggestions for the Improvement of the Transit Circle. Dr. R. Copeland.

The observations of the Moon made at the Radcliffe Observatory during the year 1883, and a comparison of the results with the tabular places from Hansen's Lunar Tables. E. J. Stone.

Note on a method of reducing the friction of the polar axis of a large telescope. A. A. Common.

June 13. Fourth catalogue of micrometrical measures of Double Stars made at the Temple Observatory, Rugby. G. M. Seabroke.

On a new Variable Star in *Monoceros*. J. E. Gore.

On the relative proper motions of 40 Stars in the Pleiades determined from micrometric and meridian observations. Professor C. Pritchard.

The Nebula in Orion. R. S. Newall.

Notes on Mr. Stone's explanation of the errors of Hansen's Lunar Tables. Professor S. Newcomb.

The apparent orbit of a Satellite of a superior planet. Dr. J. Morrison.

The physical features of *Saturn*. H. Pratt.

Ephemeris of the Satellite of *Neptune*, 1884–85. A. Marth.

Ephemerides of the Satellites of *Saturn*, 1884–85. A. Marth.

On Professor Newcomb's empirical corrections as a means of restoring an agreement between theory and observation in the case of the Moon. E. J. Stone.

Faint Stars near *Alcyone* and near β^1 and β^2 *Capricorni*. A. A. Common.

Note on the cause of the blurred patches in instantaneous photographs of the Sun. A. C. Ranyard.

Nov. 14. Observations of occultations of Stars by the Moon, 1883–84, and of phenomena of *Jupiter's* Satellites, 1884, made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

Answers to Professor Newcomb's questions on changes in the adopted unit of mean time. E. J. Stone.

Apparent places of Comet II. (Ross) 1883. J. Tebbutt.

Lateral astronomical refraction. H. M. Paul.

Sur une inégalité lunaire à longue période. C. Gogou.

Observations of the Comet of 1812 (Pons-Brooks) at its return to perihelion in 1884. J. Tebbutt.

Ephemerides of the Satellites of *Saturn*, 1884–85 (continuation). A. Marth.

Ephemerides for physical observations of *Jupiter*, 1884–85. A. Marth.

Sextant observations of Comet Pons-Brooks made on board the ship "British Envoy." Capt. P. Holdich.

Abnormal obscurity of the Moon in the late eclipse. Rev. S. J. Johnson.

The total eclipse of the Moon, 1884 October 4. W. F. Denning.

Observations of Comet Barnard 1884. J. Tebbutt.

Occultations of Stars by the Moon observed at the Davidson Observatory, San Francisco. G. Davidson.

Observations of Comet 1884 (Barnard), made at the Royal Observatory, Cape of Good Hope.

Approximate elements of Comet, 1884 (Barnard). W. H. Finlay.

The occulting eye-piece. E. J. Spitta.

A remarkable configuration of Stars in the Milky Way detected by photography. Rev. T. E. Espin.

On the periodic time of α *Centauri*. E. B. Powell.

A photometric comparison of the light transmitted by certain refracting and reflecting telescopes of equal aperture. Professor C. Pritchard.

Note on a comparison of the photometric magnitudes of the same Stars observed at Harvard College and at the University Observatory, Oxford. Professor C. Pritchard.

Observations of Stars occulted by the Moon during the eclipse of 1884 October 4. Communicated by Professor Pritchard.

The proper motions of the 460 Stars given in the R.A.S. *Memoirs*, vol. xxiii., when the places of Auwers's re-reduction of Bradley's observations are

adopted instead of Bessel's, with notes on the proper motion of *μ Piscium*. E. J. Stone.
Total eclipse of the Moon, 1884 Oct. 4. Communicated by E. J. Stone.
Occultations of Stars observed at Dun Echt during the total lunar eclipse of Oct. 4, 1884. Dr. R. Copeland.
Total eclipse of the Moon, October 4, 1884. Rev. S. J. Perry.
Note on a method of giving long exposures in astronomical photography. A. A. Common.
Note on stellar photography. A. A. Common.
The orbit of Barnard's Comet 1884. Dr. J. Morrison.
Occultations observed at Harrow during the total eclipse of the Moon, 1884 October 4. Lieut.-Col. Tupman.
On a new solar eye-piece. A. Hilger.

Dec. 12. Observations of Comet *c* 1884 (Wolf), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
On the numerical value of the coefficient of Neison's long inequality in the Moon's motion, due to the action of Mars. [Extract from a letter to Professor Adams.] C. Gogou.
On systematic errors in the reading of the circle-microscopes of the Cape Transit Circle. David Gill.
Note upon the Right Ascensions of certain standard polar Stars. Professor T. H. Safford.
Data for a graphical representation of the Solar System. A. Marth.
Spectroscopic observations made at the Earl of Crawford's Observatory, Dun Echt. R. Copeland.
Observations of Comets Pons-Brooks and Ross, 1884. A. B. Biggs.
The long duration of meteor radiant points. W. F. Denning.

1885.
Jan. 9. Ephemeris for finding the positions of the Satellites of *Uranus*, 1885. A. Marth.
Note on Professor Pritchard's comparison of the light transmitted by refracting and reflecting telescopes. W. S. Franks.
Occultations of Stars by the Moon, and phenomena of the Satellites of *Jupiter* and *Saturn*, observed at Mr. Edward Crossley's Observatory, Bermerside, Halifax, in the year 1884. J. Gledhill.
Observations of Stars occulted by the Moon during the eclipse of 1884 October 4. E. J. Spitta.
Note on an observation of *Saturn*, November 23, 1884. E. J. Spitta.

On screw-wear as affecting the N.P.D. of the Cape Catalogue for 1880. E. J. Stone.

The observations of the Moon made at the Radcliffe Observatory during the year 1884, and a comparison of the results with the tabular places from Hansen's Lunar Tables. E. J. Stone.

Note on the descriptions of two Stars in Ptolemy's Catalogue. E. B. Knobel.

Observations of occultations of Stars by the Moon, and of phenomena of *Jupiter's* Satellites, made at the Royal Observatory, Greenwich, in the year 1884. Communicated by the Astronomer Royal.

Note on the periodic time of *α Centauri*. A. M. W. Downing.

Observations of Comet *c* 1884 (Wolf), made at Stonyhurst College Observatory with the 8-inch telescope and ring micrometer. Rev. Ad. Müller.

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ADDRESS

Delivered by the President, Edwin Dunkin, F.R.S., on presenting the Gold Medal of the Society to William Huggins, D.C.L., LL.D., F.R.S.

Gentlemen,

You have already been informed in the Annual Report, just read, that the Council have awarded the Gold Medal of the Society to Dr. William Huggins for his researches on the motions of stars in the line of sight, and on the photographic spectra of stars and comets. It now becomes my pleasing duty to explain to you briefly, in a general manner, the principal grounds by which the Council have been influenced in coming to their decision.

Before doing so, however, perhaps I may be permitted to remark that no one can possibly refer to the printed list of our medallists without being impressed with the wideness of scope available to the astronomical inquirer, as illustrated by the great diversity of subjects for which the medal has been awarded by the respective Councils in past years. A glance at the names contained in the printed list shows clearly that the medals of the Society have been presented to astronomers without regard to nationality or to subject, for their original researches either in the mathematics, the ordinary observing labours, or in the literature of astronomy. For instance, I do not find that profound researches on the theories of the movements of the members of the Solar System, or on kindred mathematical subjects, have been more recognised than those relating to important tabular deductions from meridian or equatorial observations, to the original discoveries of planets and comets, or to many other miscellaneous subjects in the more popular branches of the science. On the contrary, since the first award in 1823 to the present time, original inquirers in all branches of astronomy have been found worthy recipients of our medal, a sufficient evidence of the strict impartiality of the Council. But it must be borne in mind that this, the highest scientific honour that the Society can bestow, has never been presented to anyone before his claims have been well weighed by those who, for the time being, have been the Society's representatives. The chief object of the Council, so far as my experience goes, has always been the endeavour to recognise the original works of astronomers generally whenever

any specially high merit is exhibited, or a definite advance on some point in astronomy is made; and I believe in a remark made by Sir George Airy, that "Scarcely ever has it occurred that in looking back to the award of our medals we could say that any important subject had been omitted which ought to have been taken into consideration, or that a better choice could have been made than that which we have made."

As you are all doubtless aware, the Society's gold medal was awarded in 1867 to Dr. Huggins, jointly with Dr. W. Allen Miller, for their researches in astronomical physics. The grounds for this award are most ably and eloquently given in the address of the President, Professor C. Pritchard, and I consider that I cannot do better than refer you to that address, not only for numerous details connected with the labours of these gentlemen, given with all that earnestness of language of which the author is so consummate a master, but also for an interesting, though brief, account of the progress of spectrum analysis as applied to the examination of the physical constitution of the heavenly bodies from the time when Dr. Wollaston, in 1802, first observed a few of the principal lines in the solar spectrum. I thus refer you to Professor Pritchard's address, as, in the few remarks which it will be my duty to make, I shall naturally confine myself to those observations of Dr. Huggins made subsequently to 1867, and more particularly to the special subjects named in the award, referring to his original experimental researches relating to his method for determining the motions of stars in the line of sight, and to his successful photographs of the spectra of stars and comets.

Although Dr. Huggins's first published memoir on his method of determining the relative radial motions of the Earth and stars appeared in 1868, the subject had previously occupied the attention of himself and Dr. Miller so early as 1862; for while engaged in that year on the comparison of the bright lines of terrestrial substances with the dark lines in the spectra of a few of the principal stars, with the object of obtaining information on their chemical composition, their thoughts were also directed to this question of radial stellar motion, for Dr. Huggins has remarked that at the time they were fully aware that "if the stars were moving towards or from the Earth, their motion, compounded with the Earth's motion, would alter to an observer on the Earth the refrangibility of the light emitted by them, and consequently the lines of terrestrial substances would no longer coincide in position in the spectrum with the dark lines produced by the absorption of the vapours of the same substances existing in the stars." (*Phil. Trans.*, 1868, p. 529.) Owing, however, to the insufficiency of the apparatus in these early and delicate experiments, the first results were, on the whole, of a negative character, though enough evidence was obtained to show that better instrumental means only were required to test the method to some definite conclusion. Suffi-

cient, however, was done in the early part of 1868 to enable Dr. Huggins to present, with some confidence, to the Royal Society some observations on a small change of refrangibility which he had observed in a line in the spectrum of *Sirius* when compared with a line of hydrogen. This very small displacement indicated that the star was receding from the Earth in the direction of the line of sight with a velocity of about twenty-nine miles per second.

Dr. Huggins does not claim in any way to be the first to suggest the theoretical idea of using the spectroscope for determining the effects produced by the radial motions of the stars; for I observe that in his memoir, previously quoted, he refers to the researches of Doppler, Fizeau, Clerk-Maxwell, and others who have considered this question. The researches of these physicists, however, all differ in many important respects from those of Dr. Huggins, inasmuch as they refer generally either to the theoretical explanation of the differences of colour usually found in binary stars, or to certain experiments on the influence of the motion of a source of light upon the refrangibility of its rays. The following extract from a letter, addressed to Dr. Huggins in 1867 by the late Professor Clerk-Maxwell, refers specially to M. Fizeau's valuable memoir in the *Annales de Chimie et de Physique*, Feb. 1860. After explaining his own experiments on the influence of the motions of the heavenly bodies on the index of refraction of light, he has stated that "On the other hand, M. Fizeau has observed a difference in the rotation of the plane of polarisation according as the ray travels in the direction of the Earth's motion or in the contrary direction, and M. Ångström has observed a similar difference in phenomena of diffraction. I am not aware that either of these very difficult observations has been confirmed by repetition. In another experiment of M. Fizeau, which seems entitled to greater confidence, he has observed that the propagation of light in a stream of water takes place with greater velocity in the direction in which the water moves than in the opposite direction, but that the acceleration is less than that which would be due to the actual velocity of the water, and that the phenomenon does not occur when air is substituted for water. This experiment seems rather to verify Fresnel's theory of the ether; but the whole question of the state of luminiferous medium near the Earth, and of its connection with gross matter, is very far as yet from being settled by experiment." (*Phil. Trans.*, 1868, p. 535.)

Doppler, in 1841, contended that, as the impression received by the eye and ear is not the result of the strength and period of the waves of light and sound, but that it is rather determined by the interval of time occupied by them in falling upon the eye or the ear of the observer, it follows "that the colour and intensity of an impression of light, and the pitch and strength of a sound, will be altered by a motion of the source of the light or of the sound, or by a motion of the observer, towards or from

each other." By this hypothesis Doppler conceived that he could account for the remarkable variations of colour observed in binary stars. I do not perceive, however, that he or the other physicists, who have investigated the subject, had suggested any trustworthy practical method of observation, by which the absolute amount of approach or recess of stars could be satisfactorily measured. It appears to me, therefore, that this great advance in the subject was reserved for Dr. Huggins, for the undoubted success of the method contrived by him cannot fail to be acknowledged by the results he has given, first in his memoir of 1868, and repeated in that of 1872; results which have been amply confirmed year by year from observations made at the Royal Observatory, Greenwich, at the Observatory of Potsdam, and at other places. To him, therefore, most assuredly belongs the credit of being the first astronomical physicist who gave practical life to the subject, and made the method of observation completely efficient, by which he has added a new element to our knowledge of the system of the universe.

But, gentlemen, I wish you clearly to understand that, successful as Dr. Huggins has been in contriving a method of observation which has been easily followed by independent observers, this success has not been gained without great perseverance on his part, and a determination not to be daunted by any apparent failure. From the first he was evidently convinced in his own mind of the practicability of the method, and that ultimately he would attain sufficiently trustworthy results, which would enable him to announce with confidence that he had really succeeded in measuring the amount of displacement of one of the principal lines in the spectrum of a star, and to determine from that displacement the approximate motion of that star in the line of sight. In experiments of this delicate nature, and probably of most others of a similar kind, we may naturally suppose that the observer, at the beginning of his experiments, is troubled with all sorts of difficulties; and when we consider that so much depends on the steadiness of the atmosphere, or on the accurate adjustment of the spectroscope, the telescope, and other parts of the apparatus employed, can there be any wonder that the first observations are frequently of a negative character? However, sufficient was shown by the early comparisons made by Dr. Huggins to prove that none of the stars, the lines in the spectra of which had been carefully compared, were moving in the direction of the visual ray, relatively to light, equivalent to the displacement of a line through a space equal to that which is observed between the components of Fraunhofer's D. This observation alone was a great advance. But, as I have before remarked, it was not till 1868 that Dr. Huggins, in his communication read before the Royal Society on May 14 of that year, was able to indicate with tolerable certainty a marked, though smaller, displacement of the F line in the spectrum of *Sirius*, which he considered to be the effect pro-

duced by the relative motions of the Earth and Star in the line of sight. As an illustration of the question of what are some of the difficulties experienced in these delicate observations, I think it will be appropriate to quote here the words of Dr. Huggins himself. He says:—"The chief difficulties which I have had to encounter have arisen from the unsteadiness of our atmosphere. There is sufficient light from stars of the first and second magnitude for the large spectroscope, and so far as the adjustments of the instrument are concerned, the lines in the spectra of the stars would be well defined. Unless, however, the air is very steady, the lines are seen too fitfully to permit of any certainty in the determination of coincidences of the degree of delicacy which is attempted in the present investigation. I have passed hours in the attempt to determine the position of a single line, and have then not considered that the numerous observations which I had obtained were possessed, even collectively, of sufficient weight to establish with any certainty the coincidence of the line with the one compared with it." (*Phil. Trans.*, 1868, p. 546.)

All the observations, prior to 1870, were made with the Alvan Clark Refractor of 8 inches aperture and 10 feet focal length, mounted equatorially, and fitted with a clock-movement, which carried the instrument very smoothly. In 1870, the Royal Society placed at the disposal of Dr. Huggins their large Equatorial, constructed by Messrs. Grubb & Son. This instrument is provided with a tube and object-glass of 15 inches aperture, and 15 feet focal length, and also with a second tube containing a speculum of 18 inches diameter. Either of these tubes could be attached, when required, to the declination-axis of the equatorial mounting. In 1882 the instrument was taken down, and remounted in the early part of the following year, with considerable improvements in the mounting of the tubes, which are now attached to two separate declination-axes, the one moving within the other. The two tubes can now be moved in declination independently of each other, and the one not in use can be turned away so as not to be in inconvenient positions. Both are carried by the clock-motion.

The spectroscope which Dr. Huggins had constructed in 1866 for the special objects of his research was furnished with three prisms of 60° of very dense flint-glass, through which the solar lines were very distinctly seen. To obtain a separation of the lines sufficient for his purpose, he found it necessary to employ an eye-piece magnifying ten or twelve times. The stellar lines were not, however, seen in the continued steady manner required for the accurate measurements of the small displacements observed. To obviate this inconvenience, and to ensure success in his observations, Dr. Huggins resolved to employ a larger number of prisms and a smaller magnifying power. He was fortunate in having in his possession two very fine direct-vision prisms on Amici's principle, which induced

him to attempt to combine in one instrument several simple prisms, with one or two compound prisms, which gave direct vision. By this combination of prisms an instrument was devised possessing several not unimportant advantages; but in 1868, after Dr. Huggins's first series of comparisons, an apparatus, superior in many respects to that described in his memoir (*Phil. Trans.* 1868, p. 536), was constructed and afterwards employed in his more recent observations of the displacement of the lines in stellar spectra due to the motions of the stars in the line of sight, and for other spectroscopic work.

For a further detailed account of the peculiar features of the various contrivances adopted by Dr. Huggins in his observations, I must refer you to his original memoirs for these, and for many other interesting particulars, relating to the methods employed, and the many difficulties experienced, in this delicate research, which have led him on step by step towards the successful completion of his original design.

The stars selected by Dr. Huggins in his earlier experiments were mostly those of the first magnitude, including *α Orionis*, *Sirius*, *Aldebaran*, and *Castor*, of all of which comparisons of their spectra were made before 1868; but definite results were only obtained from those of *Sirius* when compared with the F hydrogen line. For my present purpose, therefore, it will be a sufficient example if I confine my remarks wholly to that star, whose resulting radial motion was the first confidently announced as a proof of the adequacy of the method of comparison. The subject was soon taken up at other Observatories, and its principle, for the most part, confirmed.

As Dr. Huggins and Dr. Miller had previously concluded that the strong lines in the spectrum of *Sirius* were due to the presence of hydrogen, the F line was used generally in the comparisons. At the time when the observation of the displacement of this line was made by Dr. Huggins, the amount of the change of refrangibility was in wave-length 0·109 millionth of a millimetre. Assuming the velocity of light to be 185,000 miles per second, and the wave-length of F 486·50 millionths of a millimetre, it was found that the observed displacement of this line in *Sirius* would indicate a motion of recession from the Earth of 41·4 miles per second. When this observation was made, it appeared that the Earth was moving with a velocity of about 12 miles per second, from which it has been inferred that, of the combined recession of 41·4 miles per second between the Earth and the Star, 29·4 miles per second may be attributed to the motion of *Sirius* in the line of sight at that period.

Fortified with new instrumental means of the highest order, Dr. Huggins resumed his inquiry in the spring of 1872, and during a few nights sufficiently fine for these delicate comparisons, he was able to make several series of measures of the amount of displacement of the F line in the spectrum of *Sirius* with the corresponding line in the spectrum of hydrogen. This set of

observations completely confirmed the former conclusion that the star was receding from the Earth, but with a much smaller velocity; for whereas in 1868 the observed absolute radial motion of the star was found to be 29·4 miles per second, the motion determined in 1872 was from 18 to 22 miles per second. Dr. Huggins has observed on this apparent diminution of velocity that "the difference of this estimate, which is probably below rather than in excess of the true amount, from that which I formerly made may be due in part or entirely to the less perfect instruments then at my command. At the same time, if *Sirius* be moving in an elliptic orbit, as suggested by Dr. Peters, that part of the star's proper motion which is in the direction of the visual ray would constantly vary." More recent observations made at the Royal Observatory would seem to confirm this apparent change of velocity, and that the original estimate in 1868 was at the time not far from the truth. It is remarkable that a nearly constant diminution of the recession has been recorded in the Greenwich Observations from year to year, till at the present time a considerable approach towards the Sun is indicated.*

In addition to *Sirius*, the stars found by Dr. Huggins in 1872 to be receding from the Sun are *Rigel*, *α Orionis*, *Castor*, *Regulus*, and *β*, *γ*, *δ*, *ε*, and *ζ Ursæ Majoris*, while those found to be approaching the Sun are *Pollux*, *α Ursæ Majoris*, *Arcturus*,

* Through the courtesy of the Astronomer Royal, I am enabled to give in the following table the mean concluded radial motion of *Sirius*, observed at the Royal Observatory at each opposition. The measures from 1875 to the spring of 1877 were obtained with the old ten-prism spectroscope, and extended over the period from December 22, 1875 to March 17, 1877. The other measures were all obtained with the half-prism spectroscope. The years given in the first column refer to the winter season common to both years; for instance, 1877–78 means that the observations were made during the winter from November 1877 to March 1878.

Motion of Sirius in the Line of Sight, from Observations made with the Spectroscope at the Royal Observatory, Greenwich.

Opposition of	Number of Nights.	Number of Measures.	Mean Concluded Motion.
1875–76 and 1876–77	4	8	+21·1 miles per sec.
1877–78	3	8	+23·0 "
1879–80	3	10	+15·1 "
1880–81	2	4	+11·3 "
1881–82	5	22	+ 2·1 "
1882–83	3	18	− 4·7 "
1883–84	13	43	−19·4 "
1884–85	2	8	−21·5 "

In the last column the sign + denotes recession from the Sun, and the sign − approach towards the Sun.

a Lyræ, and *a Cygni*, omitting many others which indicate either recession or approach, but which had been deferred for further observation.

I have no doubt that many of the Fellows will be interested to learn that observations for the determination of the motions of stars in the line of sight now form a most important branch of the daily work in the Physical department of the Royal Observatory whenever the state of the sky permits. The results have been communicated to the Society, and they appear annually in the *Monthly Notices*. In one year, 1883, the observed amount of the displacement of usually the F or b_1 lines is given for 46 stars, of many of which the observations were made on several nights during the year. The total number of measures were 310.* The absolute results of approach or recession of corresponding stars deduced by Dr. Huggins and at the Royal Observatory have been compared by the present Astronomer Royal. The agreement between the two series of concluded values is most satisfactory, and, considering the great delicacy of the observations, the discordances are not greater than might have been expected. Some of these comparisons have been communicated to the Society by Mr. Christie, who has remarked that, notwithstanding the difficulty of observation, "it is gratifying to find that, out of the list of 21 stars which have been observed, both by Dr. Huggins and Mr. Maunder, there are only two cases of discordance, as will be seen from the table; and for both of these stars Dr. Huggins has expressed himself as dissatisfied with his observations; whilst the Greenwich results for these stars rest on too few observations at present." (*Monthly Notices*, vol. xxxvi. p. 316.) The observations of these and other stars made at Greenwich in subsequent years to the date of that communication give also generally accordant results. (*Monthly Notices*, vol. xxxviii. p. 507.)

I cannot conclude this portion of my address more appropriately than by giving the independent testimony of my late revered friend, Mr. Spottiswoode, on presenting the Rumford Medal to Dr. Huggins at the anniversary meeting of the Royal Society on November 30, 1880. I give it in his own words: "Dr. Huggins has determined the radial component of the velocity of the heavenly bodies relatively to our Earth, by

* Since writing the above, I find from the Council Report of the Proceedings of the Royal Observatory that these numbers were far exceeded in 1884, when 731 measures of displacement of either the F or *b* lines were observed, consisting of 674 measures of the F line in the spectra of 48 stars, 49 of the *b* lines in the spectra of 12 stars, and eight of the F line in the spectrum of the great nebula in *Orion*. In addition to these measures, 132 comparisons of the hydrogen or magnesium lines, with the corresponding lines in the spectrum of he Moon, were made as a check on the general accuracy of the concluded tesults of the absolute motions of the stars in the line of sight. Several measures of the displacement of the F and *b* lines in the spectra of *Venus* and *Mars*, and some observations of the relative displacement of the same lines at the east and west limbs of *Jupiter*, were also made for the same purpose.

means of the alteration of the refrangibility of certain definite kinds of light which they emit, or which are stopped by their atmospheres. The smallness of the alteration corresponding to a relative velocity comparable with the velocity of the Earth in its orbit makes the determination a matter of extreme delicacy. But as early as 1868, he had obtained such trustworthy determinations, that he was able to announce before the Royal Society that *Sirius* was receding from our Solar System with a velocity of about 29·4 miles per second. In a paper presented to the Royal Society in 1872, he has given the results obtained for a large number of stars, and has shown that some are receding and some approaching, and that there seems to be a balance of recession in those parts of the heavens, from which we have reason, from the observed proper motions, which of course can only be transversal, to conclude that the Solar System is receding, and a balance in favour of approach in the opposite direction; while yet it does not appear that the motion of the Solar System would alone account for the whole of the proper motions of the stars in a radial direction.

"The same inquiry was extended to the nebulæ, the spectrum of which consists of bright lines, and in this case it presented greater difficulties. As those nebular lines, which appear pretty certainly to be identifiable with hydrogen, are too faint to be employed in the investigation, and the others are not at present identified with those of any known element or compound, he was obliged to avail himself of a coincidence between the brightest nebular line and a line of lead. But as the coincidence is probably merely fortuitous, the results give only the *differences* of approach or recess of different nebulæ. The observations seem to show that, so far as has been observed, the nebulæ are objects of greater fixity as regards motion in space, than the stars."

Though I believe that it is no part of my duty, on the present occasion, to refer to any other researches of Dr. Huggins than those contained strictly within the grounds of the award, still, I consider that it is only proper that I should draw your attention to the subjects, at least, of some of his more important contributions to astronomical physics, which have been published since 1867. My remarks on them must, however, be very brief, but the full details of each will be found either in the *Philosophical Transactions* or *Proceedings* of the Royal Society, and in some other publications.

One of the first investigations which Dr. Huggins undertook after the erection of the Royal Society Equatorial, was the determination of the true character of the bright lines in the spectra of the nebulæ, one of which was found to be probably coincident with that of nitrogen. His paper on his eye observations of the great nebula in *Orion* gives a detailed description of the character and position of the four bright lines: the first of which he was inclined to regard as probably due to nitrogen; the second

line was found to be a little less refrangible than a strong line in the spectrum of barium, but the substance to which it belongs is doubtful; while the third and fourth lines agree in position with two lines in the spectrum of hydrogen at F and near G. An estimation was made of the probable motion of the nebula in the line of sight; and if the amount of displacement of the first nebular line from the middle of the double line of nitrogen is correct, it would correspond to a velocity of 55 miles per second from the Earth, or, taking into account the Earth's orbital motion, a recession of 40 miles per second from the Solar System is indicated. From the difficulty of the observation, this result is not given by Dr. Huggins as final, as he remarks that it is possible that the first line in the spectrum of the gaseous nebulæ is not due to nitrogen at all, and that "in consequence of the uncertainty of the character of this first line, which is single, while that of nitrogen is double, this determination can now only be made by means of the comparison of the third line with that of hydrogen. The third line becomes very faint from the great loss of light unavoidable in a spectroscope that gives a sufficient dispersive power, and the comparison can only be attempted when the sky is very clear and the nebula near the meridian." Dr. Huggins's observations of the spectra of Brorsen's Comet, and Comet II. 1868, are highly important. The three bands observed in the spectrum of the latter comet, though in similar parts of the spectrum as the three bands in Brorsen's Comet, differed considerably from them in position and character. By a direct comparison in the instrument with the spectrum of olefiant gas, the bands of Comet II. 1868 were found to be identical in refrangibility, and in other respects, with the bands in the spectrum of carbon. The spectra of Comet I. 1871, and Encke's Comet in the same year, were also examined.

Soon after the great solar eclipse of August 18, 1868, you will remember that considerable interest was excited among physical astronomers when the information was received in England that the spectroscopic observations of the red prominences showed that their spectra were discontinuous, and that, at least, three bright lines were observed. This interest was much increased when the simultaneous announcement was made, at a meeting of the Académie des Sciences in the autumn of 1868, that M. Janssen on the day following the eclipse, and Mr. Lockyer a few weeks after, had each independently succeeded in viewing the spectrum of a prominence in daylight. Before this eclipse attempts were made by several observers for the same object, and among them Dr. Huggins, but without success. But shortly afterwards, having now some indication of the position of the bright lines, he saw the spectra of the prominences at once with a small spectroscope, with which they had been previously looked for in vain. The subject for some time continued to occupy his attention, and in the following

year he communicated to the Royal Society a short paper on a method of viewing the *forms* of the prominences by means of a wide slit, the method which has since been generally in use.

Time will not allow me to refer to other short, but interesting and valuable, papers of Dr. Huggins, as I must now proceed to the second subject named in the award, and consider some of his more recent labours on the photographic spectra of stars and comets.

The successful application of photography for the delineation of celestial objects has done much to give us a clearer conception of their peculiar features and constitution. My predecessor in this Chair, at the last anniversary meeting, had the gratifying duty of recognising, on the part of the Council, their just appreciation of the finest specimen as yet produced of the details of the great nebula in *Orion*, as photographed by Mr. Common, a work which, as Mr. Stone truly remarked, has "excited the admiration of all the astronomers who had an opportunity of inspecting it." But photography has also given us the beautiful representations of the lunar face, for which we are indebted to Mr. De La Rue and many others; of numerous celestial objects, including the photographs of the late Dr. Henry Draper, who was following, in some measure, the same line of research as Dr. Huggins; of the pictures of the great Comet of 1882 and the neighbouring stars, photographed at the Cape Observatory; and of some recent beautiful photographs of stars to the ninth magnitude, near θ *Orionis* and α *Aquilæ*, taken by Mr. Common. In Mr. De La Rue's photographs of the solar eclipse of 1860, we have undoubtedly the first recorded proof of the solar origin of the red prominences. No one can deny that these brilliant results, produced by the aid of the camera, are of the highest scientific importance, although I believe that the future of photographic astronomy will exhibit a history that will far transcend what has been accomplished in the past; and that the time will come—it may not be far distant—when astronomy will be enriched even with a photographic stellar atlas, which will contain not only a classified arrangement of the positions and magnitudes of the stars, but also an indication of the probable material elements of which the larger stars are composed. As the commencement of such a work, the photographic observations of the spectra of the stars, by Dr. Huggins, will always command an honourable place.

Although the subject of photographing the spectra of some of the principal stars was only systematically taken up by Dr. Huggins since the erection of the Royal Society equatorial, he had, nevertheless, planned a series of observations more than twenty years ago. With his friend and colleague, Dr. W. A. Miller, they had jointly succeeded in obtaining a photograph of the spectrum of *Sirius*, which was exhibited to the public on a screen at a lecture delivered at the Royal Institution in 1863. Previously to this the images of the stars had been photographed

as points, but the spectrum exhibited was the first instance that the rays of a star after dispersion were recorded upon a photographic plate. Though extremely interesting and valuable as a preliminary experiment, these photographs were not of sufficient clearness to be of scientific value, a defect which was partly due to the action of the driving-clock, which did not work with the required accuracy. The observations, therefore, were for a time discontinued.

In December, 1876, Dr. Huggins communicated to the Royal Society a preliminary "Note on the Photographic Spectra of Stars" (*Proceedings*, vol. xxv., p. 445), in which he states that he had recently resumed these experiments, using for his purpose the 18-inch speculum of the Royal Society equatorial, and that Mr. Howard Grubb had successfully applied to the clock the control of a seconds pendulum in electric connection with a sidereal clock, thus obtaining a sensibly uniform motion of the telescope. From this time the excellent series of photographs of stellar spectra, which Dr. Huggins has taken, may be said to have commenced. As an illustration of the effects of the improvement in his instrumental means, he was able, at this early stage of the inquiry, to give in the above paper an enlarged copy of the spectrum of *a Lyræ*, with a solar spectrum on the same plate, taken on the next day for comparison, the plate having been allowed to remain in the instrument during the interval. Seven strong lines in the spectrum of the star are exhibited on this early photograph, all slightly shaded at the sides. The two lines of least refrangibility coincide in position with two known lines of hydrogen in the solar spectrum. After the publication of this preliminary note, Professor H. Draper contributed two articles on the same subject to the *American Journal of Science*, the first in 1877 and the second in 1879.

The mapping of the photographic spectra of stars, as carried out by Dr. Huggins, is a research of great delicacy, as a perfect definition of the bands is absolutely necessary to allow of the accurate measurement of their respective wave-lengths. It may be supposed that to obtain this satisfactorily the most careful manipulation is requisite, when it is considered that the photographic plates are only 1½ inch long by ½ inch wide, and the length of the photographic spectrum between the lines G and P in the ultra-violet about ½ an inch. The definition is usually very good, and the photographs can very easily be examined, and the position of the lines measured under a low-power microscope; and, though the solar spectrum on the plate is only ½ an inch in length, about fourteen lines may be counted between the lines H and K. The delicacy of the observation arises partly on account of the small quantity of light at the disposal of the observer, and partly to the extreme care required to obtain accurate comparisons of the star spectrum with the spectra of known substances, in order to ascertain whether the presence or absence of such and such substances may be detected in the stars. The general conclusion, from the discussion of the

different spectra, appears to show that the stars may be arranged in a connected series, the various types passing from the class of white stars, through stars more or less resembling our Sun, to the stars which shine with an orange or red light. Dr. Huggins suggests that these types of spectrum probably indicate the relative ages of the stars, or at least their relative temperature.

In Dr. Huggins's complete memoir, read before the Royal Society on December 18, 1879 (*Phil. Trans.*, 1880, pp. 669–690), special notes are given on the peculiarities of the following stars in the first or white group, *Sirius*, *η Ursæ Majoris*, *Spica*, *α Aquilæ*, *α Cygni*, and *α Lyræ*. Photographs were also obtained of several other stars, but owing to the unfavourable state of the atmosphere when they were taken, a description of their spectra is deferred. "The photographs present a spectrum of twelve very strong lines. Beyond these lines a strong continuous spectrum can be traced as far as S, but without any further indication of lines. The least refrangible of these lines is coincident with the line γ of hydrogen near G. The next line in order of greater refrangibility agrees in position with *h* of the solar spectrum. The third line is H; K, if present at all, is thin and inconspicuous. The nine lines which follow do not appear to be coincident with any of the stronger lines of the solar spectrum. These lines appear to be common to all the stars of this class, though it may be that some of the more refrangible lines are sometimes absent."* The usual time of exposure with sensitive gelatine plates was from fifteen minutes to two hours; but in the more recent trials with still more sensitive plates, the period of exposure has been reduced.

In a photograph of the spectrum of *Rigel*, taken on January 3, 1880, all the typical lines can be detected, and they are broader than those found in the spectrum of *α Cygni*, but not so broad as the lines in that of *Spica*. There is also a suspicion of lines beyond the typical group, and of two other lines between α and γ.

Taking *Arcturus* as an example of another type, it is found that it has a photographic spectrum containing a great many lines from *b* to G, and the whole spectrum is crowded with lines as seen in the solar spectrum, which makes a great dissimilarity between its spectrum and that of the class of white stars. Twenty-one of the stronger of these lines have been carefully measured and mapped, and several of them agree in position with corresponding lines in the solar spectrum. Dr. Huggins gives the wave-lengths of eighty-one lines in the spectrum of this star. On the more refrangible side of *h* the appearance of a bright band is seen which suggests a bright line,

* The observed wave-lengths of the twelve typical lines are:—

	W.L.		W.L.		W.L.
H	4340	β	3834	ζ	3730
h	4101	γ	3795	η	3717·5
H_1	3968	δ	3767·5	θ	3707·5
α	3887·5	ε	3745·5	ι	3699

on which Dr. Huggins remarks that "After a careful examination of the two negatives which I have of this star, and of positions taken from them, I have come to the conclusion that this appearance is really due to the absence of the finer lines which probably crowd the other parts of the spectrum, though they are too fine and close to be seen separately in the photographs." Beyond K there is a strong contrast in the character of the lines, for they are arranged more or less in triple and other forms of grouping, the lines being much wider and more intense. All the principal lines in the crowded portion of the spectrum have been measured and inserted in the map accompanying the original memoir. I have lately had an opportunity of examining several of the original photographs in each type, and I am glad that I am able to give my unbiassed testimony to the great dissimilarity of the lines in the spectra of the two classes of stars, and also to the exquisite definition of the lines in the photographs of both the solar and stellar spectra.

The spectrum of *Aldebaran*, a pale red star, is also crowded with lines. About fifty of the stronger lines can be measured. In the more refrangible part of the photographed portion of the spectrum the lines are more numerous than in the other portion, and of a different character, being broader, more intense, and apparently more diffused at the edges. The spectrum of *Capella*, though a white star, is a remarkable one, containing a large number of lines, on which Dr. Huggins has remarked that the photographs "exhibit a spectrum from F to beyond S, which so closely resembles the solar spectrum that a photograph of this star would, at first sight, be taken for a solar one," and that this general resemblance of the spectrum of this star with the solar spectrum would seem to indicate that *Capella* is in the same stage as that in which our Sun is.

In addition to these stellar photographs, Dr. Huggins has also taken successful photographs of the spectra of *Venus*, *Mars*, and *Jupiter*, together with a broad daylight spectrum for comparison. They, however, fail to show any additional absorption lines, or any modifications of the solar light in the photographic part of the spectrum. Photographs of the light of the Moon from limited areas of the lunar surface have been taken under different conditions of illumination, and also during partial eclipses of the Moon.

The photographs have been examined and the lines measured by a micrometer attached to a low-power microscope. The measures were then reduced to wave-lengths by the help of solar and terrestrial spectra, with the assistance of Cornu's map of the ultra-violet part of the spectrum, and of Mascart's determinations of the wave-lengths of cadmium. The spectra of *Sirius*, *η Ursæ Majoris*, *Spica*, *α Aquilæ*, *α Lyræ*, *α Cygni*, and *Arcturus*, admit of easy comparison by reference to the map which is laid down on the scale of that of Cornu.

I have already briefly referred to Dr. Huggins's direct eye-observations of the spectra of several comets and to the im-

portant deductions he has obtained from them relating to their physical constitution, but I am now desirous to draw your particular attention to a successful photograph of the spectrum of Comet I., 1882 (Wells), in which the cometary bands differ considerably from those observed in the spectra of previous comets. These bands are exhibited with great clearness in the photograph, an enlarged copy of which may be found in the *Proceedings*, R. S., vol. xxxiv. p. 149. This photograph was taken through one half of the slit on the evening of May 31, 1882, with an exposure of an hour and a half. For the convenience of accurate comparison a spectrum of *a Ursæ Majoris* was taken on the same plate through the other half of the slit. It shows a strong continuous spectrum without the appearance of any of the Fraunhofer lines, extending from about F to a little beyond H. The spectrum differs greatly from that of Comet I. 1881, as also from the spectra of the comets (about twenty) which had been previously examined spectroscopically, and contains bright lines indicating the presence of vapour of sodium, and also some other bright lines and groups of lines. "The continuous spectrum which extends from below F to a little distance beyond H contains at least five brighter spaces, which are doubtless groups of bright lines, though it is not possible in the photograph to resolve them into lines. These places of greater brightness can be traced beyond the border of the continuous spectrum on the side which corresponds to the coma of the comet on the side next the Sun. The light from this part of the comet gave a very much fainter continuous spectrum, for on the photographic plate it appears to be almost wholly resolved by the prisms into these bright groups. One or two fainter groups are suspected to be present, but they are too indistinct to admit of measurement." The beginning and ending of the bright groups are very faint, and the estimated brightest parts only are capable of being measured.

In the photographic spectrum of the great nebula of *Orion*, obtained on March 7, 1882, after an exposure of forty-five minutes, may be noticed five bright lines, as well as a narrower continuous spectrum which Dr. Huggins considers may be due to stellar light. In his previous eye-observation of the spectrum of this nebula he had found four bright lines, the brightest being coincident with the less refrangible component of a strong double line in the spectrum of nitrogen. The second line has a wave-length of 4957 of Ångström's scale, the third and fourth lines being coincident with, as I have already stated, two lines of hydrogen. In the photograph these lines are faint, but they can be satisfactorily recognised and measured. In addition to these the photographic spectrum shows a comparatively strong line in the ultra-violet, corresponding nearly to l of the typical spectrum of white stars.

Dr. Huggins's successful application of photography to the subject of these inquiries is now so far acknowledged to be an important astronomical achievement that it is hoped that others will follow his example. But any attempts to follow in his

footsteps will certainly end in failure unless the observer is in possession of instruments of the highest class as well as the necessary zeal for the work. This inquiry into the probable physical constitution of individual stars ought not to be considered completed by Dr. Huggins's experiments, but rather it should be looked upon as the commencement of a research to include the examination and classification of the spectra of all the large stars in both hemispheres. That this will be done sometime in the future I have not the least shadow of a doubt. In the meanwhile we are all able to appreciate the excellent work which our Foreign Secretary has initiated and accomplished.

In conclusion, let us not suppose for one moment that the reliable information we possess at present, relating to the peculiar apparent radial motions and physical constitution of the heavenly bodies, has been obtained without considerable personal and anxious thought on the part of those valued contributors, of different nationalities, who have devoted their time and energy in the prosecution of other delicate researches in spectroscopic astronomy, besides those which form the special subjects of our remarks to-day. I am certain that much early apparent want of success has been felt from time to time by all those physical astronomers who have so nobly enriched our knowledge in this interesting branch of astronomy, since the modern application of the spectroscope to the analysis of the light of the Sun, comets, stars, and nebulæ—a subject of investigation which was first brought prominently into notice by the publication of the remarkable researches of Kirchhoff and Bunsen in the *Memoirs* of the Academy of Berlin, 1861. Among the anxieties to which an observer is liable in delicate observations of this kind, he must always look forward to the many difficulties that are certain to arise at the commencement of a new research, not the least of which are the doubts of ultimate success, or of the astronomical utility of the question under discussion; especially in one, as in the present instance, where the observer is required to possess a good knowledge both of the methods of astronomical observation and experimental chemistry. But where there is a determination to persevere in any well-planned investigation, it is always pleasant to note when, notwithstanding occasional failures, or it may be after seasons of great observing labour and energy on the part of the observer, the anxious inquirer after knowledge conquers all difficulties at last. It often happens in the earlier experiments, as we have previously noticed, that the observer is hampered either by insufficient instrumental means, or by difficulties in obtaining the correct adjustment of the apparatus employed, which, to command success, must be as perfect as possible. But when, by practice, he becomes acquainted with the capability of his instruments, these early difficulties are usually surmounted, and he goes on step by step in his research till he perceives a dawn of light approaching, and, not far distant, the long looked-for results, to attain which he has been so eagerly working, perhaps for years. We

can, in imagination, picture to ourselves the calm satisfaction of the observer when, after carrying on his delicate experiments for a long period, he finds that he is near the end of his self-imposed labours, so that he may soon be in a position to communicate to his colleagues the successful results of his experiments, and to receive from them possibly a due recognition of the scientific value of his work.

But, though we have just seen that difficulties and anxieties may reasonably be expected in all new, and to some extent novel, experiments, let it not be thought that all the early attempts in apparently unsuccessful investigations are entirely thrown away; but, as in the case of our Medallist, who, as we have seen, has had his failures as well as successes, let them rather lead the student of nature onwards to further trials, and, if sincere in his work, he will eventually reap the reward of his zeal and perseverance. If Dr. Huggins, after his comparative failure in 1863 to obtain successful photographs of stellar spectra, or after his inability, at the same time, to decide to his satisfaction the true amount of displacement of a line in a spectrum of a star due to its motion in the line of sight, had looked with disfavour upon these interesting inquiries as far too difficult and delicate to be practically realised, and had consequently devoted his talents to other, and what at the time might have appeared more fruitful, branches of astronomy, we should not to-day have been able to recognise and admire the brilliant successes which he afterwards accomplished in his various investigations in astronomical physics, by the aid of increased experience and superior instrumental appliances.

And now, gentlemen, I have stated to you in a general manner the principal grounds which have led your Council to award the Medal to Dr. Huggins, and, after the remarks you have heard from me to-day, I am confident that you will coincide with their opinion that the important researches with which he has enriched our science are well deserving of that honour.

The President, then delivering the Medal to Dr. Huggins, addressed him in the following terms:—

DR. HUGGINS,—

I have great pleasure in presenting you with this Medal which has been honourably awarded to you by the Council. I trust you will accept it as the highest acknowledgment of your valuable services to our science which it is in their power to bestow. This is not the first time that your devotion to astronomy has been recognised from this Chair, and I hope that it is not the last, for we still find you carrying on with success your important and delicate researches. May your health be long preserved, and may astronomy long continue to receive the benefit of your talents, which I have no doubt will be the means of still further adding to our present knowledge of the constitution of the universe.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President.

EDWIN DUNKIN, Esq., F.R.S.

Vice-Presidents.

J. C. ADAMS, Esq., M.A., LL.D., D.C.L., F.R.S., Lowndean Professor of Astronomy, Cambridge.
ARTHUR CAYLEY, Esq., M.A., LL.D., D.C.L., F.R.S., Sadlerian Professor of Pure Mathematics, Cambridge.
WARREN DE LA RUE, Esq., M.A., Ph.D., D.C.L., F.R.S.
E. J. STONE, Esq., M.A., F.R.S., Radcliffe Observer.

Treasurer.

A. A. COMMON, Esq.

Secretaries.

E. B. KNOBEL, Esq.
Lieut.-Col. G. L. TUPMAN, R.M.A.

Foreign Secretary.

WILLIAM HUGGINS, Esq., LL.D., D.C.L., F.R.S.

Council.

Capt. W. DE W. ABNEY, R.E., F.R.S.
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J. RAND CAPRON, Esq.
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A. M. W. DOWNING, Esq., M.A.
J. W. L. GLAISHER, Esq., M.A., F.R.S.
J. R. HIND, Esq., LL.D., F.R.S., Superintendent of the *Nautical Almanac.*
GEORGE KNOTT, Esq., LL.B.
E. W. MAUNDER, Esq.
Rev. CHARLES PRITCHARD, D.D., F.R.S., Savilian Professor of Astronomy, Oxford.
A. COWPER RANYARD, Esq., M.A.
Lieut.-Gen. J. F. TENNANT, R.E., F.R.S.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. MARCH 13, 1885. No. 5

EDWIN DUNKIN, F.R.S., President, in the Chair.

Professor W. Steadman Aldis, M.A., University College, Auckland, New Zealand;
Lieut. Henry Edward O'Neill, R.N., Mozambique; and
William Peck, 6 Hanover Street, Edinburgh;

were balloted for and duly elected Fellows of the Society.

On the Proposed Change of the Astronomical Day. By Professor Theodor von Oppolzer.

As my views differ in some points from those which Professor Newcomb has given on page 122 of this volume of the *Monthly Notices*, I avail myself of the occasion to state in a few lines my own views on this subject. I fully agree with Professor Newcomb that the universal day will prove a great convenience, and I even think that its use will not remain limited to the reckoning of physical and meteorological phenomena, but that the time will come before long when it will be possible to introduce it, not only as railway and telegraph standard time, but as the regulator of everyday life—a hope which Mr. Sandford Fleming has so well expressed at the conference held at Washington, that I will repeat his own words. "The intelligence of the people will not fail to discover before long that the adoption of correct principles of time-reckoning will in no way change or seriously affect the habits they have been accustomed to. It will certainly sweep away nothing valuable to them. The sun will rise and set to regulate their social affairs; all

classes will soon learn to understand the hour of noon, whatever the number on the dial, whether six as in scriptural times, or twelve or eighteen or any other number. People will get up and retire to bed, begin and end work at the same periods of the day as at present, and our social habits and customs will remain without a change, depending as now on the daily returning phenomena of light and darkness." For such purposes, for the wants of civil life, the present astronomical day of Greenwich is out of the question, as the change of date would, throughout all Europe, coincide with the busiest hours of the natural day, whilst by the adoption of the Greenwich civil day, as proposed by the conference, the change of date at noon (a very inconvenient thing) takes place only in some islands of the Pacific ocean. So this day, beginning at Greenwich mean midnight, seems to me to be the only one practicable for serving as a universal standard of time. But when once such a universal time is introduced for all purposes, it is quite natural that the question must arise if there is indeed so great a necessity to retain in astronomy, and only in astronomy, a different reckoning of time. I fail to see this necessity, and I do not think that it would cause any serious trouble or confusion if a change were to be made in our astronomical reckoning, whilst a special mode of reckoning time in one science only, when all others use the generally adopted standard, will, without doubt, be a source of error and confusion. It is true that the astronomical and civil reckonings do not now agree, and that we are so accustomed to this circumstance that it but rarely leads to error. But nowadays one is obliged, when seeing an indication of an hour, to ask immediately to what meridian it belongs; we are accustomed to bear constantly in mind that there are as many times as there are meridians, and so we naturally also take heed if it is astronomical or civil time. But when we have ceased to ask on which meridian an indication of time is based, when we have learned to consider time as a given, absolute quantity, independent of locality, we may sometimes forget that there exists a special astronomical time. It is not quite right that astronomical ephemerides should form a department by themselves; they are used not only by seamen (and, for instance, in the United States navy the day is reckoned from midnight, as Rear-Admiral Rodgers states on page 176 of the Protocols of the Proceedings of the Prime Meridian Conference), but also for all sorts of calendars and other publications destined for general use, so that the difference of twelve hours may often lead to serious misunderstandings. So, for instance, when the date of an eclipse is given in astronomical reckoning, the historian, who has nearly always to do only with eclipses happening in Europe, Asia, and Northern Africa, will often find that the eclipse was a day earlier than the day which is spoken of in history, and that it happened on Sunday, whilst the records speak of a Monday.

The discontinuity which will arise from the adoption of universal time in the astronomical ephemerides would for all other publications than the *Nautical Almanac* be the same if Greenwich astronomical time were to be adopted; so, for instance, the *Connaissance des Temps*, the *Berliner Jahrbuch*, &c., will not suffer a greater discontinuity on the introduction of universal than on that of Greenwich astronomical time; and when all other publications are obliged to make a change in their reckoning, I do not see why it should be so very objectionable that the *Nautical Almanac* itself should also make a change. The astronomer of 20 or 100 years hence will not want to "bear it in mind" which reckoning of time is adopted for the given epoch, for every page of the ephemeris he is making use of will tell it him, if care is only taken, when the change is adopted in the *Nautical Almanac*, and when it passes from Greenwich time to universal time, to change also the heads of the columns, and to write instead of "mean Greenwich time," "universal time," thus clearly indicating which reckoning is employed. I entirely agree with Professor Newcomb that the data on page ii of the month should be given for Greenwich midnight instead of Greenwich noon, and that the sidereal time should be that for Greenwich midnight; also the columns on page iv should be interchanged, and the hours on pages v to xviii reckoned from midnight. But I think further that these columns should no longer bear the heading "mean Greenwich midnight," and "mean Greenwich noon," but "0^h universal time" and "12^h universal time," thus clearly indicating which reckoning of time is employed. The words *midnight* and *noon* have a purely local character like the words *evening* and *morning*; at a given instant it can be 0^h on the whole earth, if we have agreed to designate this given instant everywhere with this number, but there can be midnight only under one meridian at the same absolute instant; so the words *midnight* and *noon* are to be avoided when speaking of universal time. On page i of the month we might perhaps say, instead of "apparent noon," "at upper transit at Greenwich," as this is employed in other parts of the *Nautical Almanac*. When these indications are made, a single glance at the head of the column will inform everyone, who in future times makes use of the *Nautical Almanac*, whether the book he works with is still based on "Greenwich mean time," or already on "universal time," so that an error is nearly impossible. Indeed, I never heard of an error being caused, for instance, by the circumstance that the tables of *Jupiter*, *Saturn*, and *Uranus*, by Bouvard, or the tables of *Jupiter's* Satellites, by Damoiseau, which are used in the computations for the *Nautical Almanac*, take midnight as the initial epoch. As to the ephemerides of the planets, they ought surely, as Professor Newcomb suggests, for the sake of interpolation to be given for "0^h universal time," but I do not see any disadvantage or serious trouble which could arise from this break of half a day in the

series of ephemerides, nor do I think it a very important thing that the precepts concerning time in our books on practical astronomy should be changed. Changes occur in other branches of science which necessitate more important alterations in the respective books, and they are made in new editions without the least confusion arising. I think that generally we are more inclined to *over* than to *under* estimate the trouble of a transition period; and I think the uniformity of astronomical and civil reckoning is surely worth the little trouble we shall have to overcome, at the beginning of the change, until the new reckoning is firmly rooted in all minds.

On the Right Ascensions of the Cape Catalogues for 1850 *and* 1880. By A. M. W. Downing, M.A.

In the Introduction to the Cape Catalogue for 1850 Mr. Gill gives a comparison between the R.A.'s of that Catalogue and of the Cape Catalogue for 1880. From this it appears that there is a considerable discordance between the R.A.'s of these Catalogues depending on N.P.D. From certain other comparisons which he makes Mr. Gill concludes that the results of the Dollond Transit Instrument (contained in the 1850 Catalogue) may be accepted with considerable confidence, and appears to consider that the discordance in question is probably due to variation in the plane of collimation in the Cape Transit Circle at different altitudes, and that therefore the discordances between the R.A.'s of the 1850 and 1880 Catalogues arise from errors in the latter. Without wishing to enter into any controversy on the subject, I desire to lay before the Society some evidence, taken from comparisons of southern catalogues which I happened to have by me, which appears to throw some light on this matter. And first for the Cape Catalogues for 1850 and 1880. I have made use of the materials on pp. viii and ix of the Introduction to the 1850 Catalogue, taking the mean differences of R.A. for every 6° of N.P.D. I thus obtain the following mean differences:—

Mean N.P.D.	Mean $\Delta\alpha$ 1880–1850.	Number of Stars.	Mean N.P.D.	Mean $\Delta\alpha$ 1880–1850.	Number of Stars.
° ′	s		° ′	s	
92 55	−0·007	144	141 0	−0·164	373
98 51	− ·026	139	147 1	− ·080	296
104 58	− ·027	112	151 42	− ·062	245
112 5	− ·056	147	158 43	− ·064	188
116 51	− ·079	502	164 46	− ·027	77
122 37	− ·100	393	170 14	+ ·084	58
129 4	− ·131	358	176 38	−0·347	15
134 55	−0·149	381			

The weighted mean difference (without reduction to the equator) is $-0^s{\cdot}090$, and the total number of stars used is 3368.

By a graphical representation of these mean differences, and drawing a curve through them, the following were obtained by reading off from the curve for every 5° of N.P.D.

N.P.D.	Δα	N.P.D.	Δα
°	s	°	s
95	−0·013	135	−0·149
100	− ·021	140	− ·161
105	− ·032	145	− ·103
110	− ·048	150	− ·078
115	− ·070	155	− ·060
120	− ·091	160	− ·042
125	− ·113	165	−0·025
130	−0·134		

Thus a notable discordance depending on N.P.D. is made manifest, ranging from $-0^s{\cdot}013$ at 95° to $-0^s{\cdot}161$ at 140°.

I take next the Cape Catalogues for 1840 and 1850. By bringing up the places of the stars which are common to these two Catalogues from 1840 to 1850, using the proper motions given in the former Catalogue, or, wherever possible, those of the Cape Catalogue for 1880, and then taking the differences, and combining these differences in groups of (generally) 5° of N.P.D., we obtain the following mean differences:—

Mean N.P.D.	Mean Δα 1840–1850.	Number of Stars.	Mean N.P.D.	Mean Δα 1840–1850.	Number of Stars.
° ′	s		° ′	s	
42 4	+0·047	3	117 5	−0·011	87
56 15	+ ·030	3	122 7	− ·016	85
62 4	− ·008	6	127 24	− ·045	111
67 45	− ·009	12	132 37	− ·049	127
72 19	+ ·064	7	137 54	− ·070	83
77 32	+ ·009	12	141 55	− ·062	77
82 25	+ ·031	19	147 43	− ·075	83
86 21	+ ·038	11	152 26	− ·050	58
91 48	− ·005	11	157 39	− ·110	67
97 59	+ ·044	15	162 20	− ·072	39
102 34	+ ·024	17	167 24	− ·164	28
107 14	+ ·022	43	174 0	+0·028	18
112 34	−0·013	68			

The weighted mean is $-0^s{\cdot}041$ ($-0^s{\cdot}025$ from 80° to 140°), and the total number of stars is 1090. By proceeding exactly as in the preceding case, the reduction curve gives:—

N.P.D.	Δα	N.P.D.	Δα
°	s	°	s
75	+0·027	120	−0·020
80	+ ·027	125	− ·032
85	+ ·027	130	− ·047
90	+ ·021	135	− ·061
95	+ ·023	140	− ·067
100	+ ·029	145	− ·067
105	+ ·021	150	− ·068
110	+ ·004	155	− ·078
115	−0·011	160	−0·093

In this case also we have a considerable discordance depending on N.P.D.

The next two Catalogues compared are the Cape Catalogue for 1880 and the Melbourne Catalogue for 1870. Proceeding exactly as in the preceding case, we have the following mean differences in R.A.:—

Mean N.P.D.	Mean Δα 1880−1870	Number of Stars.	Mean N.P.D.	Mean Δα 1880−1870	Number of Stars.
° ′	s		° ′	s	
44 38	+0·015	2	117 28	−0·040	37
51 11	·000	2	122 13	− ·030	36
57 41	− ·020	4	127 28	− ·021	68
62 9	+ ·013	10	132 7	+ ·007	71
67 57	·000	9	137 23	− ·048	60
72 6	− ·003	8	141 50	− ·040	33
77 3	+ ·033	12	147 55	+ ·017	45
82 36	+ ·011	16	152 31	− ·001	209
87 17	·000	9	157 46	− ·058	130
91 45	+ ·001	14	161 55	− ·077	20
97 59	− ·006	7	168 8	− ·116	29
102 54	− ·018	6	172 39	+ ·002	42
107 27	− ·031	11	177 1	−0·074	15
113 15	−0·041	10			

The combined mean difference is $-0^s{\cdot}021$, and the total number of stars used in the comparison is 915.

By reading off from the reduction curve for every 5°, we have:—

N.P.D.	Δα	N.P.D.	Δα
°	s	°	s
50	0·000	115	−0·038
55	− ·007	120	− ·036
60	− ·002	125	− ·025
65	+ ·003	130	− ·014
70	+ ·004	135	− ·026
75	+ ·013	140	− ·033
80	+ ·017	145	− ·013
85	+ ·009	150	− ·005
90	·000	155	− ·024
95	− ·005	160	− ·069
100	− ·014	165	− ·083
105	− ·025	170	− ·067
110	−0·037	175	−0·063

The comparison of the R.A.'s of these Catalogues is very satisfactory, as, except in the immediate neighbourhood of the Pole, the discordances are small, and the range confined within reasonable limits.

In order to compare the R.A.'s of the Cape Catalogue for 1880 and 1860, I have made use of the comparison between the R.A.'s of Melbourne (1870) and Cape (1860), arranged in order of N.P.D., given by De Ball in his paper, "Untersuchungen über die eigene Bewegung des Sonnensystems,' p. 3, and applying this to the values of $\Delta\alpha$ (1880–1870) given above, we have:—

N.P.D.	Δα (1880 − 1860)	N.P.D.	Δα (1880 − 1860)
°	s	°	s
60	−0·002	115	−0·018
65	− ·007	120	− ·016
70	− ·006	125	+ ·005
75	+ ·003	130	+ ·036
80	+ ·007	135	+ ·034
85	− ·001	140	+ ·057
90	·000	145	+ ·087
95	+ ·005	150	+ ·105
100	− ·004	155	+ ·076
105	− ·015	160	+ ·031
110	−0·027	165	+0·017

Here again we have a considerable range in the discordances in R.A. depending on N.P.D.

By means of these various comparisons we have the materials for comparing the R.A.'s of each of the two Catalogues under consideration—viz. those for 1850 and 1880—with the mean of three other Catalogues. Thus we have comparisons of the R.A.'s of the 1880 Catalogue with those of Melbourne (1870) and Cape (1860); and also with those of Cape (1840) indirectly, by

means of the Cape Catalogue for 1850. Similarly we have the R.A.'s of the 1850 Catalogue compared directly with those of Cape (1840) and indirectly (through the comparison with the 1880 Catalogue), with those of Melbourne (1870) and Cape (1860). We thus find the following comparison of the R.A.'s of the Cape Catalogues for 1850 and 1880 with the mean of the three other Catalogues, arranged in order of N.P.D. :—

N.P.D.	Δα (1880−Mean).	Δα (1850−Mean).	N.P.D.	Δα (1880−Mean).	Δα (1850−Mean)
°	s	s	°	s	s
60	−0·002		115	−0·038	+0·032
65	− ·002		120	− ·041	+ ·049
70	− ·001		125	− ·034	+ ·079
75	+ ·008		130	− ·022	+ ·112
80	+ ·012		135	− ·027	+ ·122
85	+ ·004		140	− ·023	+ ·138
90	·000		145	+ ·013	+ ·116
95	− ·012	+0·001	150	+ ·030	+ ·108
100	− ·023	− ·002	155	+ ·023	+ ·083
105	− ·031	+ ·001	160	+0·005	+0·046
110	−0·039	+0·009			

As tried by this test the R.A.'s of the Catalogue for 1880 appear to be much superior to those of the Catalogue for 1850. It may, however, be objected that this comparison is unduly favourable to the 1880 Catalogue, as, if systematic discordances, arising from uncorrected proper motions, affect the comparison of the Catalogues for 1850 and for 1880 to any appreciable extent, they would affect the comparison of the 1850 Catalogue with the mean considerably more than that of the 1880 Catalogue. Although I do not think that, considering the large number of stars used in the comparison (more than 3000), there can be any considerable outstanding systematic discordance arising from the use of erroneous proper motions; still, in deference to the opinion which has been expressed on the subject, I have made a comparison of the R.A.'s of the two Catalogues with the mean of the Cape Catalogues for 1840 and 1860, thus meeting the objection referred to above. The result is as follows :—

N.P.D.	Δα (1880−Mean).	Δα (1850−Mean).	N.P.D.	Δα (1880−Mean).	Δα (1850−Mean).
°	s	s	°	s	s
95	−0·016	−0·003	130	−0·026	+0·109
100	− ·027	− ·006	135	− ·027	+ ·122
105	− ·034	− ·002	140	− ·019	+ ·143
110	− ·040	+ ·009	145	+ ·026	+ ·129
115	− ·039	+ ·032	150	+ ·048	+ ·126
120	− ·044	+ ·046	155	+ ·047	+ ·107
125	−0·038	+0·075	160	+0·042	+0·083

Although the range of discordances in R.A. depending on N.P.D. is somewhat increased for the 1880 Catalogue by this proceeding, it still shows its superiority to the 1850 Catalogue. The extreme range for the former being from $-0^s{\cdot}044$ at N.P.D. 120° to $+0^s{\cdot}048$ at N.P.D. 150°, and for the latter from $-0^s{\cdot}006$ at N.P.D. 100° to $+0^s{\cdot}143$ at N.P.D. 140°. It appears, therefore, that, as far as this evidence goes, errors in the R.A.'s of the Cape Catalogue for 1850 are the principal cause of the discordances in R.A. depending on N.P.D. which appear in the comparison of the R.A.'s of the Cape Catalogues for 1850 and 1880.

Attention may also be called to the discordances between the R.A.'s of the 1840 and 1850 Catalogues when the same instrument was used; and also to the discordances between the R.A.'s of the 1860 and 1880 Catalogues, where again the same instrument was used. It would appear, therefore, that the discordances between the 1850 and 1880 Catalogues are not necessarily due to any cause arising from the use of a different instrument in making the observations.

It may be remarked that the discordances in R.A. given in this paper throughout are the actual discordances at the respective N.P.D.'s, without reduction to the equator.

On the Star Places of the Nautical Almanac. By A. M. W. Downing, M.A.

In the *Nautical Almanac* for 1884 a change is introduced in the sources from whence the places of the Greenwich fundamental stars are taken. The mean Right Ascensions of 182 * stars have been derived (as we are informed in the Preface to the *Nautical Almanac* for 1884) from (1) the table, pp. 21–22, of the Greenwich Nine-Year Catalogue; (2) the Greenwich Clock-star List for 1879; (3) the Nine-Year Catalogue itself. The mean Declinations have been brought up from the Nine-Year Catalogue, including the corrections of table, p. 27. It appears, therefore, that the Right Ascensions of those stars which are used as clock stars at Greenwich are derived from the standard Right Ascensions of clock stars from 12-hour groups observed during the years 1868–1876, and the Right Ascensions of the remaining *Nautical Almanac* stars are taken from the Nine-Year Catalogue itself. Also that the Declinations of the *Nautical Almanac* are those of the Nine-Year Catalogue corrected so as to depend on the refractions of Bessel's *Tabulæ Regiomontanæ*, with the corresponding value of the latitude of Greenwich. In the *Nautical Almanac* for 1883 the mean places of the Greenwich standard

* Mr. Hind informs me that from 1880 onwards, the place of *α Columbæ* has been derived from the Cape and Melbourne Catalogues. This reduces the total number of stars whose places are taken from the Greenwich Catalogues to 182.

stars are derived from the Greenwich Catalogues for 1860 and 1864. In this paper I propose to discuss the systematic differences between the places of the *Nautical Almanac* stars as given in the *Nautical Almanacs* for 1883 and 1884, consequent on the change from the Seven-Year Catalogues to the Nine-Year Catalogue, confining myself to the case of those stars whose places are derived from the Greenwich Observations. The places of the stars as given in the *Nautical Almanac* for 1883 have been brought up to 1884 by applying the annual variations, and the differences taken. The stars have then been arranged in order of Declination, and the following table exhibits, in this order, the differences *Nautical Almanac* 1883—*Nautical Almanac* 1884 for the individual stars.

Name of Star.	Approx. Dec.	$\Delta\alpha$	$\Delta\delta$
	° ′	s	″
λ Ursæ Min.	+88 57	+2·040	+0·14
α Ursæ Min.	88 41	−0·088	−0·06
Cephei 51 (Hev.)	87 13	+0·775	−0·48
δ Ursæ Min.	86 36	+0·696	−0·46
ε Ursæ Min.	82 14	+0·008	+0·34
ζ Ursæ Min.	78 9	+0·365	−1·23
γ Cephei	76 59	+0·010	−0·68
β Ursæ Min.	74 38	+0·050	−0·74
β² Cephei	70 3	+0·074	−0·65
λ Draconis	69 58	+0·134	+0·15
α Draconis	64 56	+0·067	−0·14
α Ursæ Maj.	62 23	+0·140	−0·05
α Cephei	62 6	+0·050	−0·79
η Draconis	61 47	+0·238	−1·02
α Cassiopeiæ	55 54	+0·053	−0·08
γ Ursæ Maj.	54 20	+0·104	−0·63
β Draconis	52 23	+0·068	−0·81
θ Ursæ Maj.	52 12	−0·017	−0·37
γ Draconis	51 30	+0·035	−0·41
η Ursæ Maj.	49 53	+0·090	−0·51
α Persei	49 27	+0·027	−0·44
ι Ursæ Maj.	48 30	+0·084	−0·49
α Aurigæ	45 53	+0·066	+0·12
α Cygni	44 52	+0·002	−0·25
α Canum Venat.	38 57	−0·054	+0·47
α Lyræ	38 41	+0·030	−0·27
61¹ Cygni	38 11	−0·167	−0·35
β Andromedæ	+35 0	−0·003	+0·36

Name of Star.	Approx. Dec.	Δα	Δδ
	° ′	s	″
β^1 Lyræ	+33 14	+0·002	−0·25
ι Aurigæ	32 59	+0·018	−0·43
α^2 Geminorum	32 8	+0·068	+0·14
ζ Herculis	31 49	+0·024	+0·48
ρ Boötis	30 53	+0·040	+0·54
ζ Cygni	29 45	−0·014	−0·05
β Tauri	28 30	+0·057	−0·60
α Andromedæ	28 27	+0·003	−0·04
β Geminorum	28 18	+0·030	+0·15
6 Cancri	28 7	−0·013	−0·53
μ Herculis	27 47	+0·012	−0·36
32 Vulpeculæ	27 37	−0·003	−0·11
ϵ^2 Boötis	27 34	+0·014	+0·07
ψ Boötis	27 24	+0·041	−0·11
α Coronæ	27 6	+0·046	+0·24
μ Leonis	26 33	−0·003	+0·27
16 Pegasi	25 23	+0·021	−0·10
ε Leonis	24 18	+0·051	−0·15
η Tauri	23 45	−0·018	−0·25
α Arietis	22 55	+0·002	+0·10
μ Geminorum	22 34	+0·028	−0·75
η Geminorum	22 32	+0·001	−0·07
δ Geminorum	22 11	+0·055	−0·34
γ Cancri	21 53	−0·007	−0·72
A Tauri	21 46	+0·014	−0·47
δ Leonis	21 10	+0·043	+0·07
η Cancri	20 50	−0·011	−0·44
γ^1 Leonis	20 26	+0·012	+0·42
β Arietis	20 14	−0·069	+0·14
α Boötis	19 47	+0·037	+1·00
f Boötis	19 44	+0·029	−0·15
γ Herculis	19 26	−0·005	+0·20
δ Arietis	19 17	+0·002	+0·03
η Boötis	18 59	+0·025	+0·65
ε Tauri	18 55	−0·017	+0·05
83 Cancri	18 12	−0·013	−0·21
τ Boötis	18 2	+0·005	−0·02
γ Geminorum	16 30	+0·016	−0·16
α Tauri	+16 16	+0·016	−0·04

Name of Star.	Approx. Dec.	Δα	Δδ
	° ′	s	″
γ Tauri	+15 21	+0·014	−0·40
β Leonis	15 13	−0·003	+0·17
ε Aquilæ	14 55	−0·037	−0·05
ν Orionis	14 47	+0·003	−0·61
η Piscium	14 45	−0·023	+0·46
σ Arietis	14 36	−0·040	+0·44
α Pegasi	14 35	−0·026	+0·27
γ Pegasi	14 32	+0·004	−0·54
α¹ Herculis	14 31	+0·018	−0·24
ζ Aquilæ	13 42	−0·072	+0·48
ξ Geminorum	13 1	−0·023	−0·65
α Ophiuchi	12 39	−0·014	+0·44
α Leonis	12 32	+0·021	+0·10
α Cancri	12 18	−0·004	+0·23
ε Virginis	11 35	−0·002	+0·03
ω Aquilæ	11 23	−0·044	−0·27
l Leonis	11 9	−0·023	−0·12
κ Cancri	11 8	+0·026	−0·30
ε Delphini	10 55	−0·040	+0·86
ο Leonis	10 25	−0·019	+0·23
γ Aquilæ	10 20	+0·027	+0·02
ζ Pegasi	10 14	−0·069	−0·23
ρ Leonis	9 54	+0·029	−0·80
κ Ophiuchi	9 33	−0·042	+0·53
β Cancri	9 33	−0·004	+1·01
72 Ophiuchi	9 33	−0·022	+0·20
ε Pegasi	9 21	+0·024	−0·25
ο Tauri	8 37	+0·019	+0·08
π Leonis	8 36	−0·004	−0·58
ο Piscium	8 34	−0·018	−0·19
α Aquilæ	8 34	+0·009	−0·05
β Canis Min.	8 31	+0·007	+0·21
χ Leonis	7 58	−0·015	−0·77
ξ² Ceti	7 56	−0·025	−0·50
α Orionis	7 23	+0·026	−0·78
ε Piscium	7 16	+0·052	−0·46
π Virginis	7 16	+0·003	−0·97
δ Piscium	6 57	−0·058	−0·12
ε Hydræ	+6 51	+0·030	−0·30

Name of Star.	Approx. Dec.	Δα	Δδ
	° ′	s	″
α Serpentis	+6 47	+0·015	+0·03
ω Piscium	6 13	−0·020	−0·36
β Aquilæ	6 7	−0·018	+0·47
α Canis Min.	5 31	+0·103	−1·05
ι Piscium	5 0	−0·033	−0·35
ν Piscium	4 54	−0·038	−0·62
ε Serpentis	4 50	−0·012	−0·64
β Ophiuchi	4 37	−0·014	−0·21
σ Ophiuchi	4 15	−0·010	+0·13
d Leonis	4 14	−0·039	−0·36
δ Virginis	4 2	+0·007	−0·82
α Ceti	3 38	+0·002	−0·14
τ Leonis	3 30	−0·041	+0·42
δ Aquilæ	2 53	−0·042	+0·21
γ^2 Ceti	2 45	+0·020	−0·43
γ Piscium	2 39	−0·034	−0·90
τ Virginis	2 6	+0·003	−0·65
κ Piscium	+0 37	−0·019	−0·93
ζ Virginis	0 0	+0·011	+0·09
η Virginis	−0 1	−0·034	−0·50
υ Leonis	0 11	−0·029	−0·32
δ Orionis	0 23	+0·032	−0·52
η Aquarii	0 43	−0·057	−0·97
γ^1 Virginis	0 49	+0·071	−1·58
α Aquarii	0 53	−0·061	−0·79
θ Aquarii	1 10	−0·020	−0·28
ε Orionis	1 16	−0·016	−0·53
γ Aquarii	1 58	−0·028	−0·17
η Serpentis	2 56	−0·022	+0·35
δ Ophiuchi	3 24	−0·030	0·00
μ Eridani	3 28	0·000	+0·12
12 Ceti	4 36	−0·029	−0·54
θ Virginis	4 55	−0·026	−0·48
β Aquarii	6 5	−0·049	+0·08
67 Ceti	6 57	−0·028	−0·76
o^1 Eridani	7 8	−0·053	−0·96
α Hydræ	8 9	−0·019	−0·57
λ Aquarii	8 12	−0·039	+0·26
β Orionis	−8 20	−0·014	−0·92

Name of Star.	Approx. Dec.	Δα	Δδ
	° ′	s	″
θ Aquarii	−8 22	−0·026	−0·94
θ Ceti	8 47	−0·051	+0·18
β Libræ	8 57	−0·027	−0·38
ι Ceti	9 28	−0·052	−1·21
κ Orionis	9 43	−0·026	−0·37
ε Eridani	9 51	+0·009	−1·07
ε Aquarii	9 55	−0·038	−0·30
ζ Ophiuchi	10 19	−0·007	−0·98
α Virginis	10 33	−0·024	−0·21
θ Canis Maj	11 54	+0·005	+0·41
α^2 Capricorni	12 54	−0·055	−0·16
γ^1 Eridani	13 50	−0·044	−0·12
δ Crateris	14 9	−0·007	−0·31
γ Canis Maj.	15 28	−0·004	+1·17
α Libræ	15 34	−0·013	−0·53
η Ophiuchi	15 35	−0·019	−0·12
δ^2 Corvi	15 52	+0·042	−0·52
μ Hydræ	16 15	−0·030	−1·12
α Canis Maj.	16 33	+0·094	+1·34
θ Capricorni	17 42	−0·006	+0·18
α Leporis	17 54	+0·050	+1·31
ρ Capricorni	18 12	−0·076	−0·09
β Ceti	18 37	−0·055	−1·09
β^1 Scorpii	19 29	−0·020	−0·94
μ Sagittarii	21 5	−0·070	−0·11
ε Corvi	21 58	+0·026	−1·11
ε Leporis	22 32	−0·057	−1·11
β Corvi	22 45	−0·094	−0·84
15 Argûs	23 58	+0·017	−0·78
ξ Argûs	24 34	+0·016	−2·39
θ Ophiuchi	24 53	−0·013	+0·34
h^2 Sagittarii	25 8	−0·098	−0·40
λ Sagittarii	25 29	−0·005	−2·49
α Scorpii	26 10	+0·005	−0·01
δ Sculptoris	28 46	−0·028	−0·13
ε Canis Maj.	28 49	+0·016	−0·32
α Piscis Aust.	−30 14	−0·054	−0·81

The stars have been combined in convenient groups, omitting, for the R.A.'s, those within 13° of the Pole, and for both co-

ordinates *Procyon*, *Sirius*, γ *Virginis*, and 61 *Cygni*. The mean $\Delta\alpha$'s and $\Delta\delta$'s have then been graphically represented, and curves drawn through them, from which can be read off the differences corresponding to any declination between the extreme limits. The table gives the mean differences and the corresponding quantities as read off from the curves.

Mean Dec.	Mean $\Delta\alpha$	Mean $\Delta\delta$	Number of Stars.	From Curves. $\Delta\alpha$	From Curves. $\Delta\delta$
° ′	s	″		s	″
+87 52		−0·22	4		
80 12		− ·45	2		−0·41
72 55	+0·067	− ·48	4		− ·48
62 48	+ ·124	− ·50	4	+0·074	− ·49
53 16	+ ·049	− ·46	5	+ ·059	− ·44
47 43	+ ·054	− ·31	5	+ ·043	− ·24
34 13	+ ·016	+ ·13	8	+ ·026	− ·04
27 43	+ ·016	− ·10	12	+ ·015	− ·05
22 3	+ ·009	− ·21	12	+ ·012	− ·07
18 31	+ ·010	+ ·14	10	+ ·004	+ ·02
13 22	− ·014	+ ·02	19	− ·005	·00
8 26	− ·002	− ·18	21	− ·009	− ·16
+ 4 7	− ·018	− ·28	15	− ·015	− ·28
− 1 37	− ·022	− ·36	15	− ·023	− ·37
9 9	− ·029	− ·46	17	− ·027	− ·41
18 33	− ·024	− ·33	16	−0·024	−0·48
−26 27	−0·016	−0·78	9		

The next table gives the differences $\Delta\alpha$ and $\Delta\delta$, read off from the curves for every 5° from Declination +85° to −25° for $\Delta\delta$, and from +70° to −25° for $\Delta\alpha$.

Dec.	$\Delta\alpha$	$\Delta\delta$	Dec.	$\Delta\alpha$	$\Delta\delta$
°	s	″	°	s	″
			+30	+0·017	−0·03
+85		−0·29	25	+ ·013	− ·07
80		− ·41	20	+ ·009	·00
75		− ·46	15	− ·003	+ ·01
70	+0·070	− ·48	10	− ·008	− ·09
65	+ ·074	− ·49	+ 5	− ·013	− ·22
60	+ ·072	− ·48	0	− ·022	− ·37
55	+ ·063	− ·45	− 5	− ·027	− ·40
50	+ ·050	− ·33	10	− ·028	− ·41
45	+ ·040	− ·20	15	− ·027	− ·44
40	+ ·032	− ·12	20	− ·023	− ·50
+35	+0·026	−0·05	−25	−0·018	−0·62

These corrections with reversed signs have been applied to the $\Delta\alpha$ and $\Delta\delta$ for every star, excepting the four mentioned above, situated between Dec. $+50°$ and $-25°$; and it is considered that the outstanding differences are those depending on R.A. The stars have therefore been arranged in order of R.A. and combined in groups of 1^h each, and by a graphical representation of the mean differences, similar to that explained above, we obtain from the two curves which have been drawn the values of $\Delta\alpha$ and $\Delta\delta$, corresponding to the mean R.A. of each group here given:—

Mean R.A.	Mean $\Delta\alpha$	Mean $\Delta\delta$	Number of Stars.	From Curves. $\Delta\alpha$	$\Delta\delta$
h m	s	"		s	"
0 26	−0·007	−0·33	7	−0·014	−0·21
1 28	− ·030	+ ·19	6	− ·018	+ ·01
2 29	− ·001	− ·01	6	− ·009	+ ·01
3 31	− ·001	− ·12	7	·000	− ·11
4 27	+ ·002	− ·15	6	+ ·007	− ·12
5 24	+ ·024	− ·04	9	+ ·015	− ·05
6 29	+ ·009	+ ·05	7	+ ·017	− ·06
7 33	+ ·022	− ·30	6	+ ·017	− ·15
8 31	+ ·012	− ·04	7	+ ·013	− ·12
9 30	+ ·006	− ·08	7	+ ·007	− ·09
10 31	+ ·003	− ·13	7	+ ·005	− ·08
11 29	+ ·006	+ ·06	6	+ ·003	− ·04
12 32	− ·004	− ·14	7	+ ·004	− ·03
13 35	+ ·017	+ ·10	7	+ ·013	+ ·08
14 34	+ ·019	+ ·24	6	+ ·017	+ ·14
15 37	+ ·013	− ·05	5	+ ·011	+ ·10
16 29	− ·004	+ ·23	5	+ ·003	+ ·17
17 23	+ ·006	+ ·26	7	− ·002	+ ·16
18 25	− ·015	− ·12	7	− ·012	+ ·07
19 27	− ·023	+ ·26	7	− ·020	+ ·18
20 32	− ·019	+ ·29	8	− ·019	+ ·21
21 36	− ·012	− ·02	5	− ·017	+ ·06
22 33	− ·023	− ·02	6	− ·017	− ·11
23 30	−0·009	−0·36	4	−0·012	−0·27

By reading off from the curves for the beginning of each hour we have the following systematic discordances in R.A. and Dec. depending on Right Ascension:—

R.A.	$\Delta\alpha_s$	$\Delta\delta_s$	R.A.	$\Delta\alpha_s$	$\Delta\delta$
h m	s	″	h m	s	″
0 0	−0·013	−0·24	12 0	+0·004	−0·03
1 0	− ·017	− ·10	13 0	+ ·008	− ·01
2 0	− ·013	+ ·01	14 0	+ ·016	+ ·11
3 0	− ·004	− ·04	15 0	+ ·015	+ ·14
4 0	+ ·004	− ·12	16 0	+ ·008	+ ·12
5 0	+ ·012	− ·08	17 0	− ·001	+ ·17
6 0	+ ·017	− ·05	18 0	− ·007	+ ·09
7 0	+ ·017	− ·11	19 0	− ·017	+ ·13
8 0	+ ·015	− ·13	20 0	− ·019	+ ·20
9 0	+ ·009	− ·09	21 0	− ·018	+ ·17
10 0	+ ·006	− ·08	22 0	− ·017	− ·01
11 0	+0·004	−0·07	23 0	−0·014	−0·18

The differences in the last table have then been applied, with reversed signs, to the $\Delta\alpha$ and $\Delta\delta$ of each star, arranged in order of Declination, which has been used in forming the first approximation to the systematic discordances depending on Declination. The residuals may be considered to be free from discordances depending on R.A., and being treated exactly as before, give the second approximation to the values of the systematic discordances depending on Declination. This table gives the resulting mean differences and the corresponding quantities read off from the curves.

Mean Dec.	Mean $\Delta\alpha$	Mean $\Delta\delta$	Number of Stars.	From Curves. $\Delta\alpha$	$\Delta\delta$
° ′	s	″		s	
+87 52		−0·18	4		
80 12		− ·57	2		−0·45
72 55	+0·070	− ·47	4		− ·52
62 48	+ ·122	− ·57	4	+ ·073	− ·51
53 16	+ ·053	− ·43	5	+ ·061	− ·44
47 43	+ ·051	− ·31	5	+ ·043	− ·24
34 13	+ ·016	+ ·11	8	+ ·025	− ·06
27 43	+ ·015	− ·12	12	+ ·013	− ·07
22 3	+ ·004	− ·14	12	+ ·006	− ·07
18 31	·000	+ ·13	10	− ·002	+ ·04
13 22	− ·011	+ ·04	19	− ·006	+ ·02
8 26	·000	− ·15	21	− ·007	− ·14
+ 4 7	− ·013	− ·27	15	− ·012	− ·26
− 1 37	− ·018	− ·32	15	− ·020	− ·35
9 9	− ·027	− ·45	17	− ·025	− ·39
18 33	− ·026	− ·33	16	−0·024	−0·47
−26 27	−0·015	−0·75	9		

The following table gives the adopted systematic discordances in R.A. and Declination depending on Declination. As this second approximation differs so little from the first, it was not considered necessary to proceed to a further approximation.

Dec.	$\Delta\alpha_\delta$	$\Delta\delta_\delta$	Dec.	$\Delta\alpha_\delta$	$\Delta\delta_\delta$
°	s	″	°	s	″
+85		−0·28	+30	+0·017	−0·06
80		− ·46	25	+ ·010	− ·07
75		− ·52	20	+ ·001	− ·05
70	+0·072	− ·53	15	− ·006	+ ·03
65	+ ·073	− ·53	10	− ·007	− ·09
60	+ ·071	− ·50	+ 5	− ·010	− ·22
55	+ ·063	− ·47	0	− ·018	− ·33
50	+ ·050	− ·32	− 5	− ·023	− ·38
45	+ ·038	− ·20	10	− ·026	− ·40
40	+ ·031	− ·11	15	− ·026	− ·42
+35	+0·026	−0·07	20	− ·024	− ·50
			−25	−0·018	−0·62

The total systematic discordance for any star is therefore found from the last table and the last but two by a proper combination of the quantities $\Delta\alpha_\alpha$ and $\Delta\alpha_\delta$ for R.A., and $\Delta\delta_\alpha$ and $\Delta\delta_\delta$ for Declination; the sum of the discordance depending on R.A. and of the discordance depending on Declination forming, of course, the total discordance. It must, however, be borne in mind that there are but few stars in the several groups from which these systematic discordances are derived, and that therefore they must not be considered as entitled to entire confidence.

On pp. 90, 91 of Dr. Auwers' paper, which forms a Supplement to the *Berliner Jahrbuch* for 1884, he gives the corrections to reduce the systems of the *Nautical Almanac* (1883), the *American Ephemeris*, and the *Connaissance des Temps* to that of the *Berliner Jahrbuch*. By making use of these tables we have the following systematic corrections to the *Berliner Jahrbuch*, the *American Ephemeris*, and the *Connaissance des Temps* respectively, to reduce them to the system of the *Nautical Almanac* for 1884.

Corrections depending on Declination.

Dec.	*Berliner Jahrbuch.*		*American Ephemeris.*		*Conn. des Temps.*	
°		″		″		″
+75		−0·73		−0·69		−0·80
	s		s		s	
70	−0·049	− ·61	+0·015	− ·58	−0·133	− ·59
65	− ·062	− ·47	− ·028	− ·44	− ·121	− ·36
60	− ·071	− ·36	− ·059	− ·32	− ·101	− ·12

Dec.	Berliner Jahrbuch.		American Ephemeris.		Conn. des Temps.	
°	s	″	s	″	s	″
55	− ·075	− ·22	− ·074	− ·16	− ·076	+ ·07
50	− ·073	− ·20	− ·081	− ·09	− ·068	− ·04
45	− ·068	− ·10	− ·083	+ ·05	+ ·010	− ·30
40	− ·068	− ·02	− ·088	+ ·13	+ ·026	− ·27
35	− ·062	+ ·04	− ·083	+ ·18	+ ·019	− ·06
30	− ·042	+ ·02	− ·058	+ ·11	+ ·012	− ·10
25	− ·021	− ·07	− ·032	− ·06	+ ·022	− ·26
20	− ·015	+ ·13	− ·027	+ ·07	+ ·029	− ·22
15	− ·015	+ ·04	− ·031	− ·06	+ ·032	− ·46
10	− ·017	− ·17	− ·037	− ·22	+ ·012	− ·62
+ 5	− ·013	− ·10	− ·036	− ·20	+ ·001	− ·36
0	− ·012	+ ·08	− ·032	− ·12	+ ·001	− ·12
− 5	− ·017	+ ·27	− ·033	+ ·02	·000	+ ·06
10	− ·018	+ ·44	− ·035	+ ·14	+ ·002	+ ·08
15	− ·020	+ ·62	− ·039	+ ·25	+ ·003	+ ·02
20	− ·021	+ 0·86	− ·040	+ ·34	− ·001	+ ·09
−25	−0·020	+1·11	−0·037	+0·50	−0·011	+0·36

Corrections depending on Right Ascension.

R.A.		Berliner Jahrbuch.		American Ephemeris.		Conn. des Temps.	
h	m	s	″	s	″	s	″
0	0	−0·025	+0·25	−0·023	+0·20	+0·011	+0·11
1	0	− ·012	+ ·05	− ·011	+ ·08	+ ·017	+ ·01
2	0	− ·004	− ·12	− ·003	− ·10	+ ·013	− ·07
3	0	− ·002	− ·10	·000	− ·16	− ·005	− ·01
4	0	+ ·005	− ·08	+ ·009	− ·23	− ·027	+ ·07
5	0	+ ·008	− ·17	+ ·012	− ·31	− ·043	+ ·05
6	0	+ ·012	− ·25	+ ·012	− ·27	− ·042	+ ·06
7	0	+ ·012	− ·23	+ ·009	− ·19	− ·030	+ ·14
8	0	− ·002	− ·26	− ·004	− ·27	− ·022	+ ·13
9	0	− ·025	− ·31	− ·024	− ·31	− ·034	+ ·07
10	0	− ·023	− ·28	− ·019	− ·23	− ·033	+ ·09
11	0	− ·003	− ·19	+ ·001	− ·07	− ·020	+ ·15
12	0	+ ·016	− ·11	+ ·015	+ ·08	− ·010	+ ·17
13	0	+ ·022	+ ·02	+ ·018	+ ·24	− ·005	+ ·18
14	0	+ ·016	+ ·09	+ ·009	+ ·25	− ·007	+ ·10
15	0	+ ·010	+ ·21	+ ·002	+ ·20	− ·005	+ ·01
16	0	+ ·006	+ ·41	·000	+ ·32	+ ·003	− ·22
17	0	+ ·001	+ ·43	·000	+ ·35	+ ·009	− ·17

R.A.		*Berliner Jahrbuch.*		*American Ephemeris.*		*Conn. des Temps.*	
h	m	s	"	s	"	s	"
18	0	− ·010	+ ·51	− ·006	+ ·50	+ ·010	+ ·02
19	0	− ·019	+ ·34	− ·016	+ ·34	+ ·010	− ·04
20	0	− ·029	+ ·13	− ·029	+ ·07	+ ·006	− ·20
21	0	− ·035	+ ·06	− ·037	− ·04	+ ·004	− ·23
22	0	− ·036	+ ·16	− ·038	+ ·05	+ ·004	− ·10
23	0	−0·032	+0·25	−0·032	+0·15	+0·007	+0·03

On examining the comparison of the places of individual stars given above (in the first table) it will be seen that there are several cases of abnormal discordance which are not covered by the systematic corrections which have been deduced. The great majority of these appear to arise from inaccuracies in the proper motions adopted in bringing up the places of the stars from the epochs of the catalogues on which their places depend. And if we substitute what must be considered to be more accurate values of the proper motions for those adopted, we find that the abnormal discordances, in almost every instance, are reduced within ordinary limits. Thus, if we confine our attention to the R.A.'s of the Greenwich clock-stars given in the *Nautical Almanacs* for 1883 and 1884 (as these are the most important cases), and if we consider a discordance amounting to $0^s{\cdot}05$ to be an abnormal discordance, we find that there are 24 of these stars whose R.A.'s differ by more than this quantity. Now the adopted proper motions of the great majority of the *Nautical Almanac* stars are taken from Main's and Stone's determinations of proper motions of the stars in Airy's earlier Greenwich Catalogues by comparing their places in those catalogues with Bessel's reduction of Bradley. If for these adopted proper motions we substitute those determined by Auwers from a comparison of his re-reduction of Bradley with modern observations, we get a set of proper motions founded on more accurate ancient places, and with a longer interval for their determination; it would appear, therefore, that they must needs be more accurate. The epoch of the catalogue on which the star places of the *Nautical Almanac* for 1884 are founded is 1872; that on which the *Nautical Almanac* for 1883 depends is some ten years earlier; if, therefore, we apply the correction 10 (Auwers' proper motion − Greenwich proper motion) to the differences *Nautical Almanac* 1883 − *Nautical Almanac* 1884, we correct roughly for errors in the assumed proper motions. Auwers' proper motions have been extracted from *Publicationen der Astronomischen Gesellschaft*, Nos. xiv. and xvii., and the Greenwich values from the Nine-Year Catalogue. The quantities in the column "uncorrected" are the actual discordances; those in the column "corrected" are the outstanding discordances after the application of the correction to the assumed proper motion.

Name of Star.	$\Delta\alpha$ Uncorrected.	Corrected.
	s	s
ι Ceti	−0·052	−0·024
β Ceti	− ·055	− ·038
δ Piscium	− ·058	− ·053
ϵ Piscium	+ ·052	+ ·002
θ Ceti	− ·051	− ·049
β Arietis	− ·069	− ·039
o^1 Eridani	− ·053	− ·037
ϵ Leporis	− ·057	− ·063
β Tauri	+ ·057	+ ·040
α Leporis	+ ·050	+ ·029
δ Geminorum	+ ·055	+ ·030
α^2 Geminorum	+ ·068	+ ·047
α Canis Min.	+ ·103	+ ·031
ϵ Leonis	+ ·051	+ ·048
β Corvi	− ·094	− ·047
μ Sagittarii	− ·070	− ·044
ζ Aquilæ	− ·072	− ·038
h^2 Sagittarii	− ·098	− ·102
α^2 Capricorni	− ·055	− ·043
ρ Capricorni	− ·076	− ·044
α Aquarii	− ·061	− ·039
η Aquarii	− ·057	− ·045
ζ Pegasi	− ·069	− ·035
α Piscis Aust.	−0·054	−0·042

In the case of *α Canis Minoris*, Auwers' periodical corrections have been applied in forming "$\Delta\alpha$ corrected." It thus appears that in every case except two the discordances are diminished by the application of the correction, and the mean discordance without regard to sign for these 24 stars is reduced from $0^s·064$ to $0^s·042$. This appears to me to demonstrate the superiority of Auwers' proper motions, and to show how desirable it is that they, or others equally accurate, should be adopted in this country.

I may also point out that the great majority of cases of discordance in the places of individual stars which Dr. Auwers finds in his comparison of the *Berliner Jahrbuch* for 1883 with the *Nautical Almanac* for the same year (contained in the Supplement to the *Berliner Jahrbuch* for 1884 referred to above) would have disappeared if the comparison had been made for 1884 instead of for 1883. In fact, by choosing the year 1883—the first in which the *Jahrbuch* uses the Catalogue of the

Astronomische Gesellschaft, and the last in which the *Nautical Almanac* uses the Seven-Year Catalogues—Dr. Auwers has taken the most favourable case for the *Berliner Jahrbuch* and the most unfavourable for the *Nautical Almanac*. The comparison would have been more impartial and more useful if 1884 had been the year selected.

Notes and Corrections to Sir John Herschel's Synopsis of all Sir William Herschel's Measures. By Herbert Sadler.

The following notes and corrections to Sir John Herschel's "Synopsis of all Sir William Herschel's Micrometrical Measurements, &c," published in volume xxxv. of the *Memoirs*, may be considered as supplementary to those already published by Sir John Herschel in *Monthly Notices*, vol. xxviii. p. 151, and by Mr. Burnham in vol. xxxiii. p. 567, and vol. xxxiv. p. 98. These, or other notes by Mr. Burnham in the *Monthly Notices* or *Memoirs*, have not been referred to in the present paper, except in one or two cases where obvious misprints in them have been corrected. The original MSS. of Sir William and Miss Caroline Herschel have been most carefully compared with the printed catalogues in the *Philosophical Transactions*, and both of these authorities with the Synopsis itself; and in this revision many errors which had escaped previous notice have been discovered and corrected. The general tenor of these corrections is to show, even more strikingly than before, the marvellous accordance of Sir William Herschel's measures (made with a 6⅓-inch mirror roughly mounted in the open air, and with rude micrometrical appliances) with the best results of modern instruments, furnished with excellent micrometers, and driven by clockwork.

Many of the identifications have been made with the aid of the 3¼-inch Sheepshanks instrument belonging to the Society, and have in all cases been indicated as concisely as possible.

All the stars in the first three classes, with one exception (that of III. 31), have now been identified. Of those which still remain unidentified, three have been measured in position-angle, five in distance, and four only in both coordinates. The position-angles or distances of only a few of the remainder have even been estimated.

Class I.

No.

1. Column 5: *for* 1779·687 *read* 1779·816, *for* 1802·019 *read* 1802·074. Column 6: *for* 297° *read* 297° est. Columns 9 and 10: *add* 1779·747, 1″·667; 1780·309, 4″·062— : 1780·320, 2″·968.

3. Column 12: *add* Wr. 243.

4. Column 12: "Called by H. 16 *Draconis*." ♅, however, calls the star 17, *not* 16, *Draconis* in the observation of 1802·827.

7. Column 6: *for* 26°·63 *read* 26°·09.

No.

13. Column 5: *for* 1782·816 *read* 1782·762. Column 12: The star is not S. 770, as printed, or 790, as corrected by Sir John Herschel, but 720.

15. Column 6: The angle 1802·246 is given as 27° 1′ *sp* (242°·98), and with this the diagram agrees, but under date March 12, 1803, H corrects to *nf* (62°·98). The components are probably alternately variable. There is little doubt that 242°·98 is the correct angle.

16. Column 12: The angle is given *nf* in printed catalogue, "Account of the Changes &c."; *np* in second account.

20. Column 6: *for* 200°·95 *read* 200°·05.

21. Column 12: *for* P. ii. 93 *read* P. ii. 89.

23. Column 12: AC. *add* "from a preceding star."

27. Column 6: *for* 234°·20 *read* 234°·80.

28. Column 6: AC. *For* 300°·0 *read* 301°·0. Column 9: *for* 1782·91 *read* 1782·991. The second measure of AC was made with the 20-ft. reflector of 18¾-in. aperture.

30. Column 3: *for* ν^2 *Cancri read* σ^2 *Cancri.*

31. Column 12: *dele* Sir J. Herschel's note. Struve gives 39°·40, 1828·59.

33. The angle is given *sf* in the MSS., corrected by Sir John Herschel in MS. note to *nf*. It is 51 *Scorpii*, not *Libræ*.

36. The angle by diagram, date 1782·550, is 20° 42′ *np* not *nf*, but this seems impossible. It is given *nf* in "Account of the Changes." In MSS. H says, "with 460 ½ diam. of S[maller] asunder; bluish white, ash coloured." The angle under date 1803·285 is 26° 49′ *np* or *sf*.

38. Column 12: The angle is given 8° 24′ in "Continuation of an Account, &c."

41. Column 6: *for* 350°·00 *read* 350° est. The place is in error, it should be $17^h\ 42^m\ 17^s + 72°\ 59'\ 10''$.

42. Another measure of date 1782·671, "by the old micrometer" 216°·00. "I suspect a mistake in reading off one of the measures."

46. "Too far asunder for one of the first class."

47. This pair is O. Arg. S. 21208.

48. Column 6: *for* 259°·85 *read* 255°·85. This pair is AC 19.

49. Probably Σ 2880, the place given being 1° in error.

50. Column 6: *for* 311°·20 *read* 311°·20 –. I cannot find the measure 312°·77 given under date 1801·704. The MSS. and H. & S. give 312°·43, 1802·665.

54. Column 5: 1802·731, given as 1802·068 in "Continuation of an Account."

60. Cf. a note by Mr. G. Hunt in the "Observatory" for August 1881.

62. Cf. "English Mechanic," February 18 and April 1, 1881, and *Monthly Notices*, xxxvii. p. 280.

67. Column 5: *dele* ·988. Column 6: *dele nf*.

68. Column 12: *add* P. iv. 258.

69. The angle is given as 167°·40 in the MSS. and 167°·00 in the printed Catalogue.

No.

70. Column 12: *add* S. 487.

71. Column 5: *for* 1782·882 *read* 1783·060. Column 12: *dele* Σ 1422. "In Σ hæc stella [1422] = H. I. 71 est posita, auctoritate catalogi mei minoris. Sed hic est error; nam H. I. 71 = Σ 1428 sine dubio." *Pos. Med.* p. C.

72. Column 9: *for* 1782·824 *read* 1782·884.

74. Column 12: *add* 160 P. II. *Trianguli.*

75. Column 12: *dele* Σ 702? and note. It is Σ 700, and is said to be ¼° *sp* 26 *Orionis* (cf. Wollaston's "Specimen of a General Catalogue").

80. Column 5: *for* 1782·101 *read* 1783·101. Column 6: *for* 132°·83 *read* 47°·17. Column 12: *for* 42·83 *read* 47·17.

81. Column 6: *for* 210°·13 *read* 210°·91.

83. Column 5: *for* 1783·350 *read* 1783·183. H says of the measure of this date, "Note the measure was forgot to be wrote down, but it being the last taken, I find my micrometer stands at ∴ . . 14° 30′ [*nf*], which agrees well enough with the figure, but as the instrument has been touched a good deal it may have been altered."

86. The measure of 1802·742 must refer to some other star. In the MSS. it is said to be "105 *Herculis* borealior;" and yet "it is a star about 1⅓ deg. from the two stars of 107 *Herculis*; the largest of several.' Cf. H. and S. p. 298; Σ *Cat. Novus*, p. 85; *Mens. Micr.* p. 78.

87. Column 6: *for* 264°·28 *read* 264°·73.

90. Certainly Σ 2781. Cf. "English Mechanic," Aug. 13, 1880.

94. Column 12: *add* "1803 May 28. Near ½ diameter of Smaller. The diameters are full 2 to 1·7 feet."

Class II.

5. Column 12: the angle given 56° 5′ in "Continuation of an Account."

6. Column 12: the angle given 83° 28′ in "Continuation of an Account."

7. Column 5: *for* 1782·378 *read* 1782·463.

8. Column 6: *for* 1781·271 *read* 1781·690.

9. Column 12: *for* Quadruple *read* Treble.

11. Column 5: *for* 1780·161 *read* 1781·882.

12. Column 3: *for* Oct. 17 *read* Oct. 19. Column 10: *for* 5″·00 *read* 5″; and *add* in Columns 9, 10, and 11: 1779·797; 4″·375; 2.

13. Column 10: Sir J. Herschel gives 4″·02? as the measure under date 1780·537; it should be 4″·38.

16. Column 10: *for* 5″·00 *read* 5″.

17. Column 6: *for* 116°·82 *read* 117°·55. Column 7, same line: *for* 1 *read* 2.

22. Column 5: *for* 1781·728 *read* 1782·449.

31. Column 9: *add* 1782·673. Column 10: *add* 10″ or 12″.

32. This is also V 51 (and N 84, as Burnham points out). It is Σ C.G. 2332.

No.

43. Column 8: *add* AC. Column 9: *add* 1782·129. Column 10: *add* 5″ ±. Column 11: *add* est.

51. The angle in 1802 is given as 86° 55′ *sp*, but should evidently be *sf*. There is no diagram given.

52. Column 6: *for* 278°·24 *read* 278°·40.

56. Column 12: it *is* Σ 175. Rectilinear motion.

60. This is Lal. 12755. h 3876.

61. Column 12: *for* Hardy's read Harding's. Σ identifies this pair with his 788.

62. Column 5: *for* 1804·665 *read* 1802·665.

68. Column 6: *for* 261°·60 *read* 81°·60. Column 4: *for* AC *read* $C - \frac{A+B}{2}$. Column 12: *add* AB from ρ *Lyræ* 152°·2, 137″5, 1783·200.

70. Column 3: *for Sagittarii read Sagittæ*. The star is P. xx. 2. *Aquilæ*; wrongly placed in *Sagitta*.

74. Column 12: *dele* note. H's estimates refer to AC, not BC.

87. Cf. "English Mechanic," Aug. 13, 1880, May 13, 1881. It is probably h 2435.

101. This pair is said to be "1° from the star ad 49 am *Camelopardali*," *i.e.* 49 *Cam.* itself, H V. 135. The place given is therefore largely in error. This pair is Σ 1127.

CLASS III.

1. Column 10: *for* 15″21 *read* 14″·27; *for* 20″·41 *read* 20″·52. Column 9: *for* 1780·521 *read* 1780·134.

2. Column 10: *for* 15″·50 *read* 15″·08.

5. Column 10: *for* 8″·08 *read* 9″·04. Column 11: *for* 1:: *read* 3.

6. Column 5; *for* 1781·882 *read* 1781·966.

7. Columns 9, 10, and 11: *add* 1783·030; 13″·12; 1.

11. Column 9: *for* 1797·753 *read* 1779·753.

14. Column 9: *for* 1780·61 *read* 1780·16.

15. Column 3: *for* 1776 *read* 1779. Column 10: *for* 6″·87 *read* 7″·5. Columns 9, 10, and 11: *add* 1780·521; 6″·87; 1.

18. Column 6: 120°·33 in printed Catalogue, 120°·45 in MSS. Distance 8″·75, under date 1780·216; H says of this measure, "Occulted by the Moon. As fast as I could, lest I should be too late." Distance 6″·25, under date 1780·263. "Very carefully taken, both diameters included, but too large a measure."

19. Column 6: 182°·73, corrected by Sir John Herschel to 181°·44. Correct measure is 181°·73. Column 9: *for* 1781·731 *read* 1781·312.

23. Column 3: *for* "34 *Cassiop.* φ" *read* "near 34 *Cassiop.* φ.' Column 6: *for* 271°·85 *read* 268°·15. This pair is in the cluster VII. 42.

24. The distance of AC is given in the printed Catalogue as 67″·82. In the MSS. 57″·82 is substituted for 67″·82 erased. The latter is undoubtedly right.

26. Column 6: *for* 262°·35 *read* 262°·65.

No.

27. This is *k' Puppis.*

32. Column 6: *for* 238°·60 *read* 238°·42.

33. Column 10: *for* 11″·35 *read* 11″·58.

35. Column 10: *for* 15″·93 *read* 16″·93.

40. Column 6: MSS. give 137°·32 *for* 133°·62. This pair is certainly Σ 2232.

42. Σ *Cat. Novus*, p. 79. "Fortasse hæc (246) = H III. 42." H's diagram converts this suspicion into certainty.

43. This is Σ 914.

46. This is Σ 952.

50. Column 10: 7″·13, *add* "central measure."

55. This is also V. 37. AB of this is BD of *υ Coronæ.*

69. The date of the second measure of position-angle is given 1802·789 in "Continuation of an Account," not 1784·789.

71. Column 6: *for* 125°·24 *read* 125°·40.

72. So. and Σ quote H's angle as 58°·42. The only measure given by H is the one given in the text.

73. Column 6: *for* 180°·60 *read* 180°·80.

76. Column 12: *dele* S 494?

78. This is Σ 414.

80. Column 6: *for* 292°·37 read 292°·40. The R.A. of this star is 1^m too small.

83. Column 6: *for* 223°·10 *read* 316°·90; confirmed by diagram.

84. Called 40 *Lyncis* in MSS. and printed Catalogue. Σ 1342, with which Sir J. Herschel and Struve identify it, is a pair near 40 *Lyncis*, for which Σ gives 326°·9; 17″·89; mags. 8·6, 11·0. 39 *Lyncis* has nearly the same R.A., but is 15° north of this. H's measures agree admirably with those of Σ for 39 *Lyncis*; but it cannot be this.

90. Column 10: *for* 13″·60 *read* 13″·10.

91. Column 10: "central measure, not very accurate." This is Σ 379.

94. Σ 688.

96. Column 12: *add* "A third extremely faint star in the same line preceding at three or four times the distance of the other two."

105. Column 12: Σ identifies this with his 2595 in the *Cat. Novus.* Measured at the Washburn Observatory by Burnham.

113. Σ 2630.

114. Σ 953.

Class IV.

2. Struve says (*Cat. Novus*, p. 86), "Suspicor in angulo latere errorem aliquem, quale exemplum jam obtulit *α Cassiopeiæ.*" Struve's angle is 84°·96. It is very possibly V 42 = Sh 289, 31° 51′ *sp* in H being mistaken for *nf*, and the distance only belonging to *η*.

9. Column 3: *for* 47 *read* 74. Column 12: *add* "an obscure star within about 1½ min."

No.

12. "Σ 2993. Hæc stella est in vicino ψ' *Aquarii*, quam Herschelius IV. 12 nuncupat. At ψ' *Aquarii* est duplex classis quintæ, cujus distantia est 50″, cum pro IV. 12 Herschelius dederit distantiam 23″·1. At nostræ stellæ distantia est 26″ secundum cl. Southium. Hinc licet suspicari eam esse H. IV. 12." (*Cat. Novus*, p. 87.)

22. *For* f^1 *read* f^2 *Cygni.* Σ, *Cat. Novus*, p. 87.

24. Column 12: *add* Treble.

26. VI[th] Class, 1782, October 19.

28. This is the same as IV. 46, 20 *Geminorum*, Σ 924. Wrongly identified in *Memoirs* R.A.S. vol. xl., with O Σ 143.

30. Σ 1369.

31. Probably O Σ 473.

32. Column 6: *for* 90°·00 *read* 90°.

35. Column 10: *for* 25″·90 *read* 25″·90+.

36. Column 6: *for* 273° 274° *read* 266° 267°.

37. Columns 9, 10, and 11: *add* 1781·805; 19″·53; 1.

39. This is O Σ 434, h 614.

59. Column 6· *for* 200°·60 *read* 210°·80. Column 12: *dele* Sh. 272?

65. Column 6: *for* 258°·60 *read* 228°·80. It is Σ 3022.

73. Column 12: Σ shows the identity of his 586 and 587 in both the *Mens. Micr.* and *Pos. Med.*

74. Column 6: *for* 65°...70° *read* 70°...75°.

77. Column 6: *for* 333°·60 *read* 333°·40.

84. Another measure (which ♅ thinks belongs to another star) 32″.80 "central measure, a little inaccurate," 1782·988. This measure is the better of the two.

85. Column 6: *for* 350° *read* 10°. Column 11, last line, *for* 1 *read* 2.

93. Σ 2431.

95. Possibly Σ 1084.

98. Σ 817.

101. Column 9: *for* 1783·312 *read* 1783·257.

102. Column 5, *for* 1783·895 *read* 1783·224. Column 6: *for* 320°·05 *read* 219°·95. Column 9: *for* 1783·846 *read* 1782·846; *for* 1783·895 *read* 1783·224.

104. Column 10: *for* 15″·95 *read* 18″·95.

105. Column 5: *for* 1785·997 *read* 1802·235.

109. Column 5: *for* 1783· *read* 1783·739.

115. Column 6: *for* 41°·20 *read* 46°·20.

118. Unidentifiable.

121. Column 6: *for* 270°·50 *read* 270° or 271°.

123. Column 5: *for* 1783·293 *read* 1783·627.

125. Column 12: *add* h 2278.

No.

126. Column 5: *for* 1783·288 *read* 1783·621.

132. Column 6: *for* 311°·60 *read* 312°·40.

CLASS V.

3. Column 10: *for* 30″...45″ *read* 30″...35″.

6. Column 12: *for* 69° 23′ *read* 69° 28′; *for* (=339·38) *read* (=339·47).

8. Column 12: The position, however, in the MSS. is given as 97° 37′ or 82° 23′ *nf*, and 79° 37′.

9. Column 10: *for* 35″·42 *read* 33″·42. Column 12: *add* Σ 3124.

22. Column 8: *dele* AB, AC. "Has four or five near, two of which are about 20″ or 30″ from each other."

27. Burnham (Washburn Observations, I. p. 133) identifies this with Sh. 202, the place in H̥h being in error. Column 9: *for* 1781·359 *read* 1782·359.

29. Column 10: *for* 25″...30″ *read* 30″...35″. Column 12: *for* Σ C.P. 452 *read* Σ C.P. 542.

32. Column 6: *for* 280° 62 *read* 259°·38. Column 10: *for* 55″·70 *read* 55″·70+.

40. Column 6: *for* 350° ± *read* *np*.

50. Column 4: *for* AB *read* BC. Column 8: *for* AB *read* BC. Column 12: *for* AC *read* AB.

51. The same as II. 32.

57. Column 9: *for* AC *read* AB. This is the same as V. 113. It is 26 (Bode) *Orionis*; P IV. 257.

62. This is not 57 *Leonis*, but S. 617.

63. This *is* Bode 91.

64. Column 9: *for* 1785·096 *read* 1783·096.

65. Column 12: *add* Quadruple.

67. This cannot be So. 560, the distance of which, according to So., is 90″·6. Sir John Herschel queries the identity in So.'s Catalogue.

70. Column 6: *for* 277°·00 *read* 263°·00. Column 12: *add* O Σ 268, h 2657.

72. Column 12: *add* Σ 2074.

76. Columns 9, 10 and 11. *Add* 1783·600; 33″·27; 1::.

77. Column 3, *for* 214 *read* 215. Cf. Sir J. Herschel in *Memoirs* R.A.S., xl. p. 141.

79. Column 12: *for* Camelop. *read* Cassiop. It *is* 9 *Cassiopeiæ*.

81. Column 12: *for* Σ C.P. 37 *read* 36.

84. This is Σ C.P. 52; O Σ Σ 22. S 405. Not 47 *Cass.*

85. This is certainly Σ C.P. 6. The star is Lalande 335.

88. Probably the same as V. 22, *q. v.*; it is described as being near λ *Auriga*, 3′ or 4′ *nf* it. Cf. So. 472 A–C.

90. Column 6: *for* 331°·80 *read* 208°·20.

No.

96. This is almost certainly the same as h 3122; the R. A. being 1^m 20^s too large, and the N.P.D. 1° 14′ too great in H h; h 3122 is W. M. T. Z. 147, No. 1.

99. Column 6: *for* 0°·60 *read* 0°·80.

102. Column 11, line 1: *for* 1 *read* est. "Too low to call it a measure."

104. Column 12: *add* "40′ *sp* ε *Sagittæ*."

108. Column 12: *add* Δ 36.

109. Column 12: *add* h 785.

110. Column 5; *for* 1783·320 *read* 1783·740.

112. Column 12: *add*—This is Σ cat. generalis 746 = Σ C.P. 233, 6^h 26^m 53^s·8 νπδ 67° 47′ 7″ (1880).

113. = V. 57; = *Orionis* 26 (Bode); = 257 P. iv. *Tauri*; = Σ C.P. 144; = Sh. 49.

115. Column 12: *to* "central measure" *add* "inaccurate." It is h 365.

116. = VI. 5 with a closer *comes*.

122. Column 6: *for* 157°·6 *read* 157°·1.

124. This is *Lacaille* 4726. Howe has found the principal star to be a close pair. H's distance marked "very inaccurate."

128. Column 10: *for* 41″·80 *read* 41″·96.

131. Column 12: *add* P. xv. 14.

135. This is Σ 1122. Column 9: *add* 1783·268. Column 10: *add* 14″·78. Column 11: *add* 1. Column 12: *add* "perhaps a little inaccurate," To the measures of 1783·734 the following note is appended. "The observation page 371 [1783·268] and this observation do not agree; nor can I surmise what could occasion the mistake of 371." The observation of page 371 is, however, the correct one, that of 1783·734 being in error in distance; Σ gives 4°·87 : 15″·460 : 1830·59, agreeing excellently with H's 185°·00 : 14″·78 : the stars being of equal magnitudes, 7^m·1, according to Σ.

137. Column 9: *for* 1783·803 *read* 1783·808.

Class VI.

1. Column 6: on one side of the page in the MSS. the angle is given as 92°·53, on the other side as 92°·20. Sh. give 92°·20. Column 10: the distance 107″·83 is the mean of two, 105″·16 and 110″·468, the latter being marked "better"; the distance 111″·72 is the mean of two, 112″·812 and 110″·625, the latter being marked "too small"; *for* 110″·00 *read* 110″. To the observation of 1780·687 H appends the following note: "Colour of a dark red ink, but darker than I can recollect to have seen any star."

2. Sh. give H's distance 1781·641 as 50″ 6‴, but it is clearly written 50″ 18‴ [50″·30] in the MSS., and with this the printed Catalogue agrees.

4. Column 3: *dele* 5 and 6 *Capric. α.* This is not *α Capricorni*, but a faint and unequal pair preceding $α^1$ and $α^2$.

5. Column 12: *add* this is AC of V. 116.

6. Column 12: *add* this is h 3040.

8. Column 12: *add* Σ 9, App. I.

No.

10. Column 6: *add sf* 1781·800, and with this the whole subsequent history of the star agrees. The angle in 1781·827 should evidently be 176°·23.

11. Column 5: *add* 1781·838. Column 6: *add* 305°·08. Column 7: *add* 2.

12. Column 12: *for* 73° 20′ *read* 73° 29′.

13. Column 6: *for sf read* 10° ±.

14. Column 10: *for* 81″·33 *read* 81″·03.

15. Column 12: *add* Identical with VI. 89.

17. Column 9: *dele* 1781·786. Column 10: *dele* 128″±. Column 11: *dele* est.

20. Column 12: *add* O Σ 73 (with close *comes*).

22. Column 12: *add* This is Σ 1752, close pair.

26. Column 6: *for* 98°·53 *read* 81°·47. Column 12: *add* "should be sf by diagram."

30. Column 12: *add* diameter of *Capella*, by two measures, 2″·86, 1780·682. *For* 61·23 *read* 61° 23′.

32. Column 12: *add* OΣ 413; close pair.

38. Column 3: *for* 64 *Draconis read* 65 *Draconis*. Column 12: *add* OΣΣ 200.

39. Columns 5 and 9: *for* 1786·882 *read* 1781·882.

42. AC. The angle 74°·30 has been erased in the MSS. and 74°·07 substituted. The distance of AC is given as 197″·31 in the printed Catalogue, and in the MSS. these figures have been erased and 160″·70 substituted. Column 12: *add* "Has three stars following."

44. The angle in the printed Catalogue is 112°·52 and in the MSS. 112°·50; 31′ being altered with the pen to 30′. Cf. "English Mechanic," Sept. 21, 1883.

51. Burnham in his Sixth Catalogue identifies this with 1, not 2, *Serpentis*.

54. Unidentifiable. It is *not* III. 25.

57. Column 12: *add* S. 799.

60. Column 12: *dele* Triple. It may be V. 47.

63. "A third nearly in the same direction and a little more than twice the distance."

65. 15 *Monocerotis.*

66. Column 12: *add* diameter by mean of 5 measures: 1781·972: 1″·37.

67. Column 12: *add* Dawes 5; close pair.

68. Lal. 10165.

77. Column 12: *add* central measures.

89. Column 12: *add* P. xiii. 219, 220.

91. In the field with γ *Geminorum*, 3′ or 4′ north of it. Triple 20 ft.

93. Column 5: *for* 1873·633 *read* 1783·633.

96. Column 12: *add* Σ 464.

98. Column 12: *add* P. iv. 24, 25; O Σ Σ 45.

100. Column 12: *add* OΣΣ 238.

No.

105. Column 10: *for* 111″·48 *read* 101″·48.

112. The angle is given as 277°·4 in MSS. and printed Catalogue; should be diminished by 180°, and be 97°·4. 82°·60 is clearly wrong.

113. Column 10: *for* 205″·73 *read* 145″·73. Column 12: *for* Σ 394 *read* ΣC.P. 394; and *add* Sh. 131. This star is called ξ *Virginis* by Sh.

117. Burnham in his Tenth Catalogue identifies this with S. 663, there being an error of 16′ in the Decl. of ♅h.

120. Column 8: *add* AB. Column 9: *add* 1783·622. Column 10: *add* 84″·15. Column 11: *add* 1. Column 12: *add* P. xix. 67.

145 New Double Stars.

8. Column 12: *add* Σ 2769.

26. This is 36 *Crateris*. The place is in error.

28. Column 12: *add* P. xiv. 212.

49. Column 12: *add* h 4256. A.C. 8 (close pair).

50. Column 12: *add* h 4321.

67. Column 12: *add* Σ 550.

70. Column 12: *add* Sh. 126.

74. Column 12: *add* h 947.

76. Column 12: *add* O Σ 14.

81. Burnham (*Memoirs*, R.A.S. xlviii. p. 289) identifies this with ν′ *Coronæ*.

85. Σ 2521.

86. O Σ 401.

89. Column 12: *add* Σ 2687, S. 753.

93. Column 12: *add* Σ 479.

94. O Σ 168 *rej*.

97. Column 12: *for* H. V. III. *read* H. V. iii.

101. According to Cincinnati Observations V. this is W. Mural Circle Z. 134, No. 133.

102. Measured in Cincinnati Observations VI.

117. Column 12: *add* h 5356.

130. Σ 2826.

134. Σ 2699 is near.

135. h 3151.

138. According to Burnham this is O. Arg. 20475, but in Cincinnati Observations vi. it is W. C. 8814.

143. Σ 1668.

1885, *March* 11.

On the Value of the Long Inequality in the Motion of the Moon due to the Disturbing Action of the Planet Mars. By Edmund Neison.

In the *Monthly Notices* for November (vol. xlv. p. 1) there is a communication by M. Gogou on the difference between the values found by us for the coefficient of the long inequality in the motion of the Moon with the argument: the mean motion of the Moon plus twenty times the mean longitude of *Mars* minus twenty-four times the mean longitude of the Earth.

The difference between M. Gogou and myself may be briefly stated thus. Whilst we both agree that the true value of the coefficient of this term when found *in this way* is only a small fraction of a second of arc, whereas M. Gogou's computations lead to values amounting to less than one thousandths of a second of arc, mine lead to values nearly a thousand times greater—to almost as large a quantity as that found in a similar way by M. Delaunay for the coefficient of the term of similar character due to the action of *Venus*, and having the argument: eight times the mean longitude of *Venus* minus thirteen times the mean longitude of the Earth.

There is more attached to this difference, *as thus stated*, than is thought by M. Gogou, who assumes it to be immaterial, as may be seen by an examination of the origin of the similar discordance between the values obtained by Hansen and Delaunay for the coefficient of the *Venus* term already mentioned.

As M. Gogou's calculations have been carried out with so much care, skill, and elaborateness, I should have been disposed to look for the source of this remaining discordance in some unsuspected deficiencies in my own far less elaborate work. But an examination of his memoir indicated a more probable origin. It was this. In calculating the values of the coefficients denoted by B, I retained the terms depending on the fifth and seventh powers of the eccentricities of *Mars* and the Earth, but in his calculation M. Gogou has omitted to do this. This I pointed out in my Note in the *Monthly Notices* for March 1882 (p. 266), and it seemed to me to offer a most probable explanation of the difference between my revised results and those of M. Gogou. I say revised results, for I had already in the *Monthly Notices* for March 1878, or four years earlier, pointed out that the very large value given in my first communication, in November 1877, was far too great, as the ordinary methods of calculating the coefficients b^i which I had employed were not sufficiently accurate for this special term.

In his present communication, M. Gogou returns to the consideration of this point and calculates the effect of certain small subsidiary terms of the fifth order, which were included by me in my calculations, but were omitted by him from his own investigations. He shows that the omission of these terms fails to account for the existing discordance.

But this result is really beside the question, for as a reference to my Note will show, it is clearly not to these terms of the fifth order to which I allude in my remarks. M. Gogou has failed to see the point of my criticism, as, indeed, my reference to terms of the seventh order might have shown him had he not disregarded it.

I will, therefore, now make my meaning unmistakable.

When we expand Δ^{-s}, or the s^{th} power of the reciprocal of the geocentric distance of *Mars* in the form of the series

$$(a''')^{-s}\Sigma\left[B_{\frac{s}{2}}\right]^{i}_{i+k}\cos\{[in''-(i+k)n''']t+E\},$$

the coefficients have the form

$$\left[B_{\frac{s}{2}}\right]^{i}_{i+k}=(e''')^{k}(e'')^{i-k}\{N_0+N_1(e''')^2+N'_1(e'')^2+N_2(e''')^4$$
$$+N'_2(e''')^2(e'')^2+N''_2(e'')^4+\ldots\}$$

where N_0, N_1, N_1' . . . are numerical coefficients.

In the ordinary development of the planetary theory, the terms involving N_1, N'_1, &c., are very much smaller than the first term depending on N_0, and can be neglected, therefore, in nearly every case. But in the present case this is by no means true, for owing to the large value of i, and the magnitude of both a and e''', the terms depending on N_1 and N_2 are nearly as large as that depending on N_0. They must therefore be retained. Now, this is what I have done, but it is what M. Gogou has omitted to do.

It must not be supposed that this omission is necessarily unimportant, because as the terms depending on N_0 are so small, even if those depending on N_1 were as large, their sum would still be unimportant. The results depending on $N_0{}^k$ are small, putting $N_0{}^k$ to denote the value of N_0 in the coefficient

$$\left[B_{\frac{s}{2}}\right]^{i}_{i+k},$$

because of the mutual relations between them. But as the same relations do not exist amongst $N_1{}^k$ as amongst $N_0{}^k$, it is easy to see that the mutual relations which destroy the one will not destroy the other. Hence the terms in N_1 ought to yield far larger results than the terms in N_0.

It is to this difference in our investigations that I ascribe the existing discordance in our results, I having retained many more terms in my calculations than have been included by M. Gogou in his more detailed and elaborate work.

I must add that having neither M. Gogou's memoir nor my own calculations of this term with me in Natal, I am quite unable until my return to England to separate these different portions of my work, and so clearly prove the accuracy of this view of the origin of the discordance between our results.

The complete value of the coefficient of this term practically depends on two functions—one arising from the direct action of *Mars* on the motion of the Moon as disturbed by the action of the Sun; and the other depending on the direct action of the

Sun on the perturbations in the motion of the Moon produced by the action of the planet.

In the preceding remarks I have confined myself to the former of these two portions, as it is the sole one which has been dealt with by M. Gogou, who, like Delaunay, has overlooked entirely the second more important portion. It is this second portion which forms the only real difficulty in the accurate calculation of the terms of this kind. It is the omission of this second portion by Delaunay which explains the discordance between him and Hansen with regard to the values of the long inequalities due to *Venus*, and it is the calculation of this second portion which seems to have so completely baffled Hansen in his attempt to deal with it in a numerical form.

But until this additional portion has been properly computed it cannot be said that the value of this term has been shown to be insensible, as believed by M. Gogou.

I had hoped to have ere this finished and published a complete determination of the real values, not only of this term, but also of both Hansen's terms of long period; but being unable out here in Natal to obtain a copy of Pontécoulant's *Théorie de la Lune*, a number of whose developments I have used in my subsidiary calculation, I am forced to delay this until I have recalculated nearly the whole of these developments—probably nearly a year's additional work.

Natal Observatory:
1885, *Feb.* 3.

Observations of Barnard's Comet (b 1884) made at the Natal Observatory, Durban. By Edmund Neison.

In the telegram sent to this Observatory on July 22, the North Polar Distance of this comet was erroneously given as 120° instead of 127°; so, though looked for most carefully, it was not discovered before the night of August 11. It was a faint, rounded, nebulous mass, with a central condensation. Sketches were made of the appearances of the comet on the nights of August 12 and 21, and September 13 and 16. The following notes were also recorded.

August 12.—Round hazy body with a hazy nucleus, and a faint tail-like extension.

August 16.—Very faint. Rounded preceding edge and faint tail. No distinct nucleus.

August 18.—Comet faint nebulous mass, without definite edges or nucleus. Slight evidence of tail on following side.

August 21.—Comet very faint. About 2′ in diameter. Two tiny points of light in the centre resembling 15-magnitude stars, which they probably were.

September 13.—Comet about 2′ in diameter, and decidedly condensed towards the centre.

September 16.—Comet seemed to glitter in the condensed centre as if there were one or two nuclei, or possibly very small stars, shining through the comet, as a number of faint stars were visible near. Diameter 2'·5; of condensed portion 0'·9. Slight trace of tail follows the condensed nucleus.

September 18.—Comet 3½' in diameter. Nearly round, and brighter than before. Decided nucleus.

Ten days' cloudy weather stopped further observation. On September 28 and 29 the comet was too near the Moon to be visible. Then cloudy weather intervened till November 4, when the comet was no longer visible.

The following observations were made with the parallel-wire micrometer of the 8-inch Equatorial of the Natal Observatory. The apparent centre of the condensed portion of the comet was observed. Owing to the very limited range of the micrometer, which is better suited for double star than for cometary work, some difficulty was found in finding comparison stars. The observations need no correction for refraction.

Apparent Places of Barnard's Comet.

Date. 1884.	Durban Mean Time.	App. R.A. 1884.	Log. Par. Factor.	App. Decl. 1884.	Log. Par. Factor.	Comp. Star.
	h m s	h m s		° ′ ″		
Aug. 12	10 30 8	17 1 49·90	8·6989	−36 43 52·3	8·3347	*a* & *b*
16	11 28 15	17 17 8·61	8·7873	−36 20 41·1	9·1123	*c*
18	11 10 52	17 24 44·21	8·7646	−36 7 39·4	8·9999	*d*
20	9 48 8	17 32 25·06	8·5957	−35 52 17·5	8·3641*n*	*e*
21	10 47 0	17 36 35·84	8·7257	−35 43 30·8	8·8109	*e*
Sept. 13	10 5 59	19 11 48·30	8·6044	−30 27 14·8	8·8736	*f*
16	10 13 34	19 23 52·18	8·6314	−29 18 20·8	9·0280	*g*
16	10 25 35	19 23 55·14	8·6316	−29 18 17·3	9·0274	*h*
18	9 44 42	19 31 39·46	8·5362	−28 38 5·8	8·8989	*i*

Comparison Stars.

*.	Name.	Authority for Adopted Place.	Adopted R.A.	Mean Decl. (1884)	Reduction to Apparent Place.	
			h m s	° ′ ″	s	″
	Lacaille 7123	Cape Cat. 80 (Stone)	16 58 30·00	−37 3 58·1	+3·80	+ 1·2
	Lacaille 7113	" "	16 57 54·70	−36 34 41·5	+3·80	+ 0·8
	* Anon.	Cape Tr.Cir.Obs.1884	17 16 53·80	−36 20 56·9	+3·88	+ 0·7
	* Anon.	" "	17 24 19·28	−36 4 18·8	+3·83	+ 1·6
	* Anon.	" "	17 34 30·33	−35 44 24·9	+3·83	+ 2·6
	* Anon.	Gould's Zone Obs.	19 10 19·82	−30 33 43·1	+3·62	+11·4
	* Anon.	"	19 23 48·61	−29 18 33·3	+3·57	+12·5
	* Anon.	"	19 23 50·59	−29 10 13·8	+3·57	+12·5
	Lacaille 8175	Cape Cat. 80 (Stone)	19 31 41·78	−28 52 4·7	+3·55	+13·2

Each place of the comet is founded on ten comparisons in Right Ascension and ten in North Polar Distance.

Natal Observatory:
1885, *Feb.* 3.

Spectroscopic Results for the Motions of Stars in the Line of Sight obtained at the Royal Observatory, Greenwich, in the year 1884. No. VIII.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. xxxvi. p. 318, vol. xxxvii. p. 22, vol. xxxviii. p. 493, vol. xli. p. 109, vol. xlii. p. 230, vol. xliii. p. 81, and vol. xliv. p. 89. The observations were made with the "half-prism" spectroscope, one "half-prism" with a dispersion of about 18½° from A to H being used, except in a few cases of bright stars, mentioned in the Remarks, where a train of two "half-prisms" with a dispersion of 80° from A to H was used. An eyepiece with a magnifying power of 14 was employed throughout.

The cylindrical lens has always been used in front of the slit as in the observations made previously to 1881. A slip of metal coated with Balmain's luminous paint inserted immediately behind the measuring pointer has been frequently employed to give a phosphorescent illumination of the field.

The observations of the Moon and of the sky spectrum have been made as a check on the general accuracy of the results.

The bright $H\beta$ line in the spectrum of γ *Cassiopeiæ* was much fainter in 1884 than when observed in 1880, 1881, and 1883. It seemed also fainter for the observations made in September than for those made in August.

Motions of Stars in the Line of Sight, in Miles per Second, observed with the Half-prism Spectroscope.

(+ denotes Recession; − Approach.)

The initials M and N are those of Mr. Maunder and Mr. Nash respectively.

Date. 1884.		Obs.	No. of Meas.	Line	Earth's Motion in M per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
						a Andromedæ.		
Aug.	7	M	2	F	−13·5	+ 4·2	− 1·4	Definition fair.
	11	M	3	F	−12·9	−13·5	− 9·2	Star-line fairly well defined.
	12	N	2	F	−12·7	−30·9	−34·9	Star-line faint.
	25	M	2	F	−10·3	−21·6	−18·0	Definition fair.
Sept.	4	M	2	F	− 8·1	−29·9	−27·1	Definition fair.
	10	M	2	F	+ 6·6	−22·1	−19·2	Definition fair.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Sept.	18	M	2	F	− 4·6	−15·2	−12·5	Definition fair.
	20	M	4	F	− 4·0	− 6·3	− 2·4	Definition poor.
Oct.	22	M	2	F	+ 5·0	−16·9	−24·3	
	24	M	2	F	+ 5·6	−20·7	−17·0	Star-line fairly well seen.
	28	N	2	F	+ 6·7	−13·6	−12·3	
Nov.	6	M	2	F	+ 9·0	−47·3	−37·1	Definition good.
	15	M	2*	F	+11·2	−33·2	−37·8	Star-line not well defined.
Dec.	17	M	4	F	+16·4	−39·8	−32·2	Measures considered rough.
						β Cassiopeiæ.		
July	21	M	1	F	−11·1	− 6·2	− 9·9	Images very steady.
Aug.	7	M	2	F	−10·9	+12·6	+13·1	Spectrum exceedingly faint.
	11	M	2	F	−10·8	+41·6	+33·6	Spectrum and star-line very faint.
	14	N	2	F	−10·6	+22·6	+23·3	Spectrum very faint.
	25	M	2	F	− 9·8	−33·0	−24·8	Definition poor.
Sept.	4	M	2	F	− 8·7	+ 9·1	+ 8·7	Star-line fairly well defined.
	10	M	2	F	− 8·0	−26·8	−27·1	Star-line very faint.
	11	N	3	F	− 7·9	+10·5	+13·8	
	18	M	2	F	− 6·8	+ 9·9	+10·0	Definition good.
	20	M	2	F	− 6·5	−24·5	−14·9	Definition fair.
						γ Pegasi.		
Aug.	12	N	2	F	−12·7	+10·1	+12·7	
Sept.	4	M	2	F	− 7·4	−11·8	−10·9	Measures rough.
	10	M	2	F	− 5·7	−37·2	−32·2	Measures rough.
	18	M	5	F	− 3·4	− 5·7	− 3·0	Star-line ill defined.
	20	M	2	F	− 2·8	+20·1	+26·9	Definition poor.
Oct.	28	N	3	F	+ 8·7	−48·7	−48·7	Star-line very faint.
Nov.	6	M	2	F	+11·1	− 0·5	+ 4·4	Definition fair.
						γ Cassiopeiæ.		
Aug.	11	M	2	F	−11·7	−16·9	−14·2	Star-line fairly well defined.
	25	M	2	F	−11·1	− 1·5	− 4·6	Definition very bad.
Sept.	4	M	2	F	−10·3	− 2·2	− 0·3	Measures very difficult.
	10	M	2	F	− 9·6	−20·6	−19·9	Measures exceedingly rough.
	11	N	2	F	− 9·5	−39·1	−39·6	
	18	M	2	F	− 8·6	−26·2	−15·0	Star-line seen with greatest difficulty.
	20	M	2	F	− 8·3	−14·4	− 7·7	Star-line faint.

Date. 1884.		No. Obs.	of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
						δ Cassiopeiæ.		
Aug.	11	M	2	F	−12·3	+ 9·6	+ 9·2	Star-line well defined, but spectrum faint.
	14	N	2	F	−12·3	+ 2·0	+ 3·9	
Sept.	11	N	2	F	−10·5	+ 5·7	+ 2·1	
	18	M	2	F	− 9·6	−33·7	−25·7	Spectrum faint.
	20	M	2	F	− 9·3	−22·6	−17·5	
						β Arietis.		
Feb.	21	M	2	F	+17·6	−55·0	−55·7	
Nov.	6	M	2	F	−10·9	−14·7	− 5·5	
						α Arietis.		
Nov.	20	N	2	F	+ 7·3	+ 4·9	+ 6·4	
						γ Persei.		
Feb.	15	M	2	F	+15·5	−49·1	−51·3	Star-line a difficult object.
	21	M	2	F	+15·4	+31·7	+30·3	Star-line faint and very ill defined.
						β Persei.		
Feb.	15	M	4	F	+17·4	−44·0	−50·7	Star-line difficult to bisect.
Aug.	11	M	2	F	−16·5	+ 9·2	+10·3	Spectrum faint, but star-line fairly well defined.
Sept.	10	M	2	F	−15·3	+33·8	+34·2	Star-line seen with difficulty.
	18	M	2	F	−14·3	+39·4	+38·4	Spectrum fairly well seen.
Oct.	24	M	2	F	− 6·6	+20·9	+26·0	Star-line very difficult to see.
	28	N	2	F	− 5·5	− 2·4	+ 7·5	Star-line broad & diffused
Nov.	6	M	2	F	− 2·9	−27·9	−20·5	
	7	N	2	F	− 2·6	−10·1	−11·1	
	8	M	2	F	− 2·3	−10·6	−14·2	Star-line not well defined.
	20	N	2	F	+ 1·4	−25·7	−28·7	
Dec.	17	M	3	F	+ 9·3	−66·0	−52·7	
						α Persei.		
Feb.	15	M	2	F	+16·2	−66·7	−67·8	Star-line difficult to bisect.
Sept.	10	M	2	F	−14·9	−22·7	−27·2	Star-line fairly well seen.
	18	M	2	F	−14·2	+ 3·9	+ 6·2	Definition fair.
Oct.	24	M	2	F	− 7·7	−12·4	− 6·0	Star-line very faint.
	28	N	2	F	− 6·7	−53·5	−56·3	
Nov.	7	N	2	F	− 4·0	−35·5	−36·9	
	8	M	4	F	− 3·8	− 0·2	0·0	Star-line very ill defined.
Dec.	17	M	2	F	+ 7·2	−34·9	−30·8	

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
						δ Persei.		
Nov.	8	M	2	F	− 4·7	+30·3	+36·4	Star-line faint, but well defined.
						η Tauri.		
Feb.	15	M	2	F	+18·8	−40·7	−40·3	Measures difficult.
Nov.	8	M	2	F	− 3·7	+ 4·0	+ 3·7	Star-line faint, but well defined.
	20	N	2	F	+ 0·3	−31·6	−31·9	
						Aldebaran.		
Jan.	24	M	2	F	+15·7	+17·4	+19·4	Star-line seen with difficulty.
Feb.	6	M	2	F	+17·6	+ 9·6	+10·5	Spectrum tremulous; star-line ill defined.
	15	M	2	F	+18·4	+ 8·6	+16·0	Definition good.
	21	M	2	F	+18·6	+17·5	+22·6	Definition very bad.
Mar.	12	M	2	F	+17·9	+46·7	+27·9	Definition very bad.
	20	N	2	b_1	+17·0	+ 2·7	+ 4·3	
	24	M	2	b_1	+16·4	+26·8	+24·5	Star-line very faint.
Nov.	8	M	4	F	− 6·7	+57·2	+54·2	Star-line faint and difficult to bisect.
	20	N	2	F	− 2·9	+ 8·4	+ 7·1	Spectrum tremulous. Star-line faint.
Dec.	15	M	2	F	+ 5·3	+34·7	+29·8	Star-line ill defined.
	17	M	2	F	+ 6·0	+18·0	+16·0	Star-line very faint.
						Capella.		
Feb.	11	M	2	F	+15·4	+22·4	+37·0	Star-line well defined.
	15	M	2	F	+15·9	+11·8	+12·7	Star-line very well defined.
	29	N	2	F	+17·0	−12·3	− 9·4	Measures doubtful. Sky hazy.
Mar.	20	N	2	b_1	+16·8	− 1·8	+ 1·5	Measures difficult.
	29	N	2	b_1	+16·0	+11·6	+ 9·8	
Nov.	8	M	2	F	− 9·4	+36·1	+44·9	Star-line fairly well seen.
Dec.	15	M	2	F	+ 1·3	−11·8	−10·3	Small, but unmistakable displacement towards the *blue.*
	17	M	2	F	+ 1·9	+15·5	+21·2	
						Rigel.		
Jan.	24	M	2	F	+12·3	− 5·3	− 3·2	Star-line not well seen.
	28	M	2	F	+13·0	+12·4	+24·4	Measures considered good.
Feb.	6	M	2	F	+14·3	+ 5·4	+ 3·3	Spectrum tremulous; star-line fairly distinct.
	11	M	2	F	+14·9	+44·7	+54·9	
	12	N	2	F	+15·0	+21·8	+16·1	

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Feb.	15	M	2	F	+15·3	+19·8	+23·4	Definition very good.
	18	M	2	F	+15·5	+ 0·2	+ 0·9	Two prism train. Star-line difficult to see.
	21	M	2	F	+15·7	+19·6	+20·9	Star-line only well seen by glimpses.
Mar.	12	M	2	F	+15·8	+23·7	+17·8	Star-line difficult to see.
Nov.	20	N	2	F	− 4·4	+41·8	+39·5	
Dec.	15	M	2	F	+ 2·6	+13·0	+12·4	Star-line seen well defined by glimpses.
	17	M	2	F	+ 3·2	+22·0	+20·4	Star-line faint.
						γ Orionis.		
Jan.	28	M	2	F	+13·7	+ 3·0	+ 8·8	Spectrum bright and fairly steady.
Feb.	11	M	4	F	+16·1	+ 9·2	+ 8·7	
	15	M	2	F	+16·6	+ 1·8	+ 9·2	Definition good.
	18	M	2	F	+17·0	−11·7	−10·2	Two prism train. Star-line faint.
	21	M	2	F	+17·2	+ 0·9	+ 3·4	Star-line fairly well seen.
Mar.	10	M	2	F	+17·8	− 7·5	−10·7	Star-line fairly well defined.
	12	M	2	F	+17·8	−10·2	−11·0	Definition poor.
Dec.	15	M	2	F	+ 1·7	−13·1	−10·7	Star-line fairly defined.
	17	M	4	F	+ 2·4	− 4·1	− 2·9	Spectrum unsteady and star-line faint.
						β Tauri.		
Jan.	28	M	2	F	+13·9	−11·8	− 9·8	Measures considered good.
Feb.	11	M	2	F	+16·5	−38·5	−42·2	Star-line well defined.
	12	N	2	F	+16·7	−21·1	−25·5	
	15	M	4	F	+17·1	−14·1	−15·0	Definition fair.
	18	M	2	F	+17·4	−24·6	−31·5	Two prism train. Measures difficult.
	21	M	2	F	+17·7	−29·6	−38·3	Star-line well seen.
Mar.	10	M	2	F	+18·5	−38·6	−33·9	Star-line fairly well defined.
	12	M	2	F	+18·5	−19·6	−18·5	Definition poor.
Dec.	15	M	2	F	+ 1·2	−22·0	−19·2	Star-line fairly defined.
	17	M	2	F	+ 1·9	−31·8	−25·5	Spectrum bright and fairly steady.
						δ Orionis.		
Jan.	28	M	2	F	+12·8	−44·0	−40·4	Star only seen by glimpses.
Feb.	11	M	2	F	+15·2	−14·8	−11·7	Star-line very faint and ill defined.
	15	M	2	F	+15·7	+ 9·8	+12·3	Star-line faint but seen well by glimpses.
	18	M	2	F	+16·0	+14·8	+16·8	Two prism train. Star-line exceedingly faint.
Dec.	15	M	2	F	+ 1·2	− 8·6	− 7·2	Measures considered rough.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
						ε Orionis.		
Feb.	11	M	2	F	+15·0	−20·5	−18·5	Star-line very faint and ill defined.
	15	M	2	F	+15·5	+24·2	+27·5	Star-line faint, but seen well by glimpses.
	18	M	2	F	+15·9	+ 5·1	+11·4	Two prism train. Measures considered fairly good.
Dec.	15	M	2	F	+ 0·8	+ 4·7	+ 6·8	Star-line only seen well by glimpses.
						ζ Orionis.		
Feb.	11	M	2	F	+14·7	−26·7	−28·7	
	15	M	2	F	+15·2	−11·9	− 6·6	Star-line faint, but seen well by glimpses.
	18	M	2	F	+15·6	− 2·4	− 1·6	Two prism train. Measures considered fairly good.
Dec.	15	M	2	F	+ 0·5	+19·4	+20·6	Star-line only seen well by glimpses.
						κ Orionis.		
Feb.	11	M	2	F	+13·4	− 8·9	+ 0·6	Star-line too faint for satisfactory measures.
	15	M	2	F	+13·9	+14·1	+11·9	Star-line faint, but seen well by glimpses.
						α Orionis.		
Mar.	20	N	3	b_4	+17·7	+31·2	+29·9	Star-line broad and diffused.
	24	M	4	b_1	+17·6	+35·9	+33·5	Definition good.
						β Aurigæ.		
Feb.	2	N	1	F	+12·4	−14·8	−12·4	Spectrum faint.
	15	M	2	F	+14·8	− 3·2	− 1·9	Measures considered good.
Dec.	17	M	2	F	− 0·6	−14·8	−15·2	Star-line broad and ill defined.
						γ Geminorum.		
Feb.	15	M	2	F	+14·2	−30·8	−29·3	Star-line seen well.
Mar.	10	M	2	F	+17·7	+15·7	+14·3	
	15	M	2	F	+18·0	−26·5	−27·6	Star-line well seen, but a *most* difficult one to bisect.
						Sirius.		
Jan.	24	M	2	F	+ 5·5	−16·2	−16·4	Definition bad.
	28	M	3	F	+ 6·4	− 5·5	− 6·6	Spectrum very tremulous.
Feb.	6	M	4	F	+ 8·4	−31·9	−26·2	Spectrum tremulous; clouds passing.
	11	M	4	F	+ 9·4	−36·8	−34·2	
	12	N	2	F	+ 9·6	−31·9	−30·6	Spectrum tremulous.
	15	M	4	F	+10·1	−33·0	−30·9	Star-line slightly displaced towards the *blue*.

Date. 1884.	Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Feb. 18	M	4	F	+10·6	−17·6	−22·3	Two prism train. Measures considered satisfactory.
Mar. 10	M	4	F	+13·3	−36·4	−35·2	Star-line very ill defined.
12	M	4	F	+13·5	+ 3·3	+ 0·2	Star in much mist and spectrum faint.
15	M	4	F	+13·7	− 5·7	− 5·6	Star-line well seen.
April 10	M	2	F	+13·9	−37·5	−37·1	Spectrum very faint.
Dec. 15	M	4	F	− 4·5	−25·8	−29·4	Star-line well seen.
17	M	4	F	− 4·0	−15·2	−15·7	Star-line fairly well seen.
					Castor.		
Jan. 24	M	1	F	+ 5·1	+ 4·3	+ 7·6	Star-line very difficult to see.
Feb. 6	M	4	F	+ 9·0	+12·4	+10·5	Star-line very ill defined.
11	M	2	F	+10·4	+ 3·2	+10·0	
15	M	2	F	+11·5	+23·6	+31·5	Measures considered good.
Mar. 15	M	2	F	+16·8	− 1·3	− 3·7	Star-line difficult to besect.
					Procyon.		
Feb. 6	M	4	F	+ 7·3	+ 0·9	+ 1·5	
11	M	4	F	+ 8·7	+16·1	+28·0	Star-line very well seen.
12	N	2	F	+ 9·0	+37·5	+43·9	
15	M	2	F	+ 9·8	− 5·4	− 5·5	Spectrum steady.
Mar. 10	M	4	F	+14·9	−26·4	−25·4	Star-line very well defined.
15	M	4	F	+15·7	−33·3	−33·7	Definition good.
April 10	M	4	F	+17·5	+ 9·1	+ 4·3	Star-line very difficult to bisect.
Dec. 15	M	2	F	− 0·9	−12·6	−12·1	Star-line very difficult to hold steadily.
					Pollux.		
Feb. 6	M	2	F	+ 8·0	−38·5	−33·8	
11	M	2	F	+ 9·4	−38·1	−38·5	
15	M	4	F	+10·5	−62·2	−61·4	Star-line frequently seen well.
Mar. 15	M	2	F	+16·4	−36·8	−39·8	Star-line *very* faint.
24	M	2	b_1	+17·4	−50·1	−47·4	Star-line clearly seen.
					α Hydræ.		
Mar. 24	M	2	b_1	+10·7	+15·1	+19·3	Star-line very difficult to see.
					Regulus.		
Feb. 6	M	2	F	− 3·4	+ 6·0	+ 6·0	Star-line ill defined.
Mar. 15	M	2	F	+ 8·6	+20·0	+18·1	Star-line somewhat difficult to bisect.

Date. 1884.	Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Concluded Motion of Star. Estimd.	Remarks.
April 10	M	2	F	+14·7	− 5·9	− 3·9	Star-line broad and ill defined.
12	N	2	F	+15·0	−19·4	−15·0	Spectrum somewhat faint.
28	M	2	F	+17·1	− 8·0	+ 2·2	Spectrum faint and rather unsteady.
May 13	N	2	F	+17·9	+ 5·7	+ 7·2	
30	M	2	F	+17·5	−11·9	− 9·3	Measures very difficult.
				γ Leonis.			
Mar. 24	M	2	b_1	+10·9	− 3·0	− 8·2	Star-line not well seen.
				β Leonis.			
April 10	M	2	F	+ 9·3	−37·3	−31·7	
28	M	2	F	+13·4	−53·4	−53·5	Spectrum unsteady and faint.
May 22	N	2	F	+16·7	−41·5	−42·2	Spectrum faint; star-line indistinct.
				ε Virginis.			
Mar. 24	M	2	b_1	− 1·1	+ 1·0	+ 1·1	Star-lines seen with great difficulty.
				Spica.			
April 5	N	1	F	− 1·8	−37·7	−38·8	Measure very difficult and rough.
May 30	M	2	F	+13·2	−15·8	−13·2	Spectrum very tremulous.
				Arcturus.			
Mar. 24	M	2	b_1	− 4·8	−53·0	−49·7	Star-lines seen very well.
April 5	N	2	F	− 1·6	−49·8	−49·1	Measures difficult.
12	N	3	F	+ 0·3	−55·1	−54·3	
28	M	2	F	+ 4·4	−38·9	−41·5	Star-line only seen by glimpses.
May 13	N	2	F	+ 8·0	−68·6	−73·0	
22	N	2	F	+ 9·8	−53·5	−59·3	
30	M	3	F	+11·3	−54·4	−55·1	
June 2	M	2	F	+11·8	−47·2	−44·6	Spectrum faint.
26	N	3	F	+14·6	−51·6	−55·7	
July 12	N	2	F	+15·3	−64·6	−64·1	Star-line very faint.
Aug. 5	M	2	F	+14·3	−52·9	−51·2	Measures difficult.
29	M	2	F	+11·1	−39·4	−47·4	Definition bad.
Sept. 25	M	2	b_1	+ 5·2	−53·5	−49·0	Star-lines seen with great difficulty.
				α Coronæ Borealis.			
April 28	M	2	F	− 0·3	+41·0	+44·8	Star-line not well seen.
May 22	N	2	F	+ 4·7	+16·3	+17·9	Star-line somewhat diffused.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
June	2	M	2	F	+ 6·8	+ 7·2	+ 8·0	Star-line not well seen.
	26	N	2	F	+ 10·4	+ 16·1	+ 17·3	Star-line diffused.
July	17	M	2	F	+ 12·3	− 60·7	− 54·4	Definition poor. Displacement evidently large towards the *blue*.
Aug.	5	M	2	F	+ 12·8	+ 23·8	+ 30·9	Definition fair, but spectrum faint.
Sept.	2	M	2	F	+ 11·2	− 27·8	− 19·8	Observations discordant.
						α Ophiuchi.		
June	26	N	4	F	+ 3·7	− 29·8	− 32·8	
July	17	M	2	F	+ 8·3	− 14·2	− 16·7	Star-line very ill defined.
Aug.	5	M	2	F	+ 11·6	− 20·4	− 19·8	Spectrum faint. Star-line diffused.
	22	M	2	F	+ 13·6	− 38·4	− 36·4	Unmistakable displacement towards the *blue*.
	23	N	2	F	+ 13·7	− 36·0	− 36·8	Spectrum faint.
Sept.	2	M	2	F	+ 14·4	− 62·4	− 55·3	Star-line seen distinctly.
						γ Draconis.		
Sept.	25	M	4	b_1	+ 4·7	− 24·3	− 32·9	Measures very difficult.
						Vega.		
May	13	N	2	F	− 6·5	− 22·0	− 21·4	
	22	N	2	F	− 5·6	− 21·0	− 22·7	
June	26	N	2	F	− 1·2	− 60·3	− 58·8	Measures difficult.
July	12	N	2	F	+ 1·1	− 36·1	− 39·2	
	17	M	2	F	+ 1·8	− 41·3	− 39·7	Spectrum bright.
	19	M	2	F	+ 2·0	− 38·5	− 44·1	Star-line difficult to bis
	30	N	2	F	+ 3·5	− 49·4	− 52·1	Star-line difficult to bi
Aug.	7	M	2	F	+ 4·5	− 30·3	− 41·9	Measures considered s factory.
	19	M	2	F	+ 5·9	− 34·8	− 32·2	
	21	N	2	F	+ 6·1	− 38·0	− 37·1	
	22	M	2	F	+ 6·2	− 33·7	− 36·6	Definition good.
	23	N	2	F	+ 6·3	− 37·9	− 40·3	
	29	M	2	F	+ 6·9	− 20·3	− 25·1	Definition good.
Sept.	2	M	2	F	+ 7·2	− 45·4	− 39·5	Definition fair.
	4	M	2	F	+ 7·4	− 33·5	− 32·7	Spectrum bright an
	10	M	2	F	+ 7·8	− 33·3	− 37·3	Definition poor.
	12	M	2	F	+ 7·9	− 25·4	− 24·0	Definition good.
	17	N	2	F	+ 8·2	− 52·2	− 50·9	
	18	M	2	F	+ 8·2	− 49·5	− 40·3	Definition good.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Oct.	22	M	2	F	+ 8·4	−23·9	−27·7	Measures considered good.
	25	N	3	F	+ 8·3	−86·3	−86·6	Misty. Measures difficult.
Nov.	6	M	2	F	+ 7·6	−40·7	−31·0	Spectrum bright and steady.
	7	N	2	F	+ 7·5	−32·0	−31·1	
						γ Lyræ.		
Aug.	19	M	2	F	+ 6·2	−42·2	−35·8	Spectrum faint.
Sept.	12	M	4	F	+ 9·0	−25·8	−30·9	Spectrum faint but steady.
						ζ Aquilæ.		
July	17	M	2	F	+ 1·9	−62·1	−43·9	Spectrum faint.
Aug.	19	M	2	F	+ 9·2	−11·8	−12·5	Spectrum faint.
Sept.	10	M	2	F	+12·7	−32·2	−27·4	Spectrum rather faint.
	12	M	2	F	+13·0	−44·3	−43·8	Spectrum steady.
Oct.	22	M	2	F	+14·7	−49·2	−53·4	Spectrum very faint.
						δ Aquilæ.		
Sept.	12	M	4	F	+14·1	−14·2	−12·1	Star spectrum very faint; displacement practically nil.
						δ Cygni.		
Aug.	22	M	2	F	+ 2·1	−29·8	−27·9	Definition fair.
Sept.	12	M	2	F	+ 4·6	+28·2	+24·1	Definition good.
	17	N	3	F	+ 5·1	−35·5	−35·7	Star-line somewhat diffused.
Oct.	22	M	2	F	+ 7·8	−43·1	−35·4	Star-line difficult to bisect.
						Altair.		
June	26	N	2	F	− 6·4	−36·7	−41·0	
July	17	M	2	F	− 1·1	−38·1	−34·0	Star-line fairly well seen.
	19	M	2	F	− 0·7	−39·1	−34·4	Star-line difficult to bisect.
Aug.	5	M	2	F	+ 3·7	−39·8	−37·9	Measures considered good.
	19	M	2	F	+ 7·2	−23·2	−23·6	Definition fair.
	21	N	2	F	+ 7·6	−41·3	−37·4	
	22	M	2	F	+ 7·9	−26·4	−26·2	Definition fair.
	23	N	2	F	+ 8·1	−36·7	−36·5	
	25	M	2	F	+ 8·5	−30·0	−27·4	Measures considered satisfactory.
	29	M	2	F	+ 9·5	−48·8	−49·4	Spectrum faint.
Sept.	1	N	1	F	+10·1	−36·5	−39·8	Cloud passing; measure doubtful.
	4	M	2	F	+10·7	−37·3	−35·3	Definition good.
	12	M	2	F	+12·2	+ 9·8	+11·7	Definition poor.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Sept.	17	N	2	F	+13·1	−52·5	−54·7	
	18	M	2	F	+13·2	−19·3	−16·4	Spectrum tremulous.
Oct.	22	M	2	F	+16·2	+ 0·7	+11·4	Star-line exceedingly ill defined.
	25	N	2	F	+16·2	−46·6	−50·4	Star-line broad and diffused.
	28	N	2	F	+16·2	−48·6	−45·3	
					γ Cygni.			
Sept.	27	M	2	b_1	+ 6·7	+ 5·9	+ 3·4	Definition bad.
Oct.	22	M	2	F	+ 9·3	−25·6	−31·4	Star-line very faint.
					a Delphini.			
Aug.	19	M	2	F	+ 3·0	−29·4	−27·6	Spectrum exceedingly faint.
	22	M	2	F	+ 3·8	−40·0	−40·2	Marked displacement towards the blue.
Sept.	12	M	2	F	+ 8·7	+ 3·0	+ 3·6	Spectrum steady, but very faint.
	18	M	2	F	+ 9·9	−50·6	−36·7	Star-line seen with great difficulty.
Oct.	22	M	2	F	+15·0	+46·8	+40·2	Measures considered fairly good.
					a Cygni.			
July	19	M	2	F	− 5·2	−35·3	−32·7	Star-line very faint.
	21	M	2	F	− 5·0	−28·6	−32·9	Star-line seen with difficulty.
Sept.	12	M	2	F	+ 2·6	−35·3	−32·7	Star-line well defined.
	17	N	3	F	+ 3·4	−41·8	−41·3	Star-line faint.
	20	M	3	F	+ 3·8	−45·2	−42·3	Star-line fairly well defined.
	25	M	2	b_1	+ 4·5	− 6·2	−13·8	Definition bad.
	27	M	2	b_1	+ 4·8	−33·7	−36·9	Measures considered satisfactory.
Oct.	22	M	2	F	+ 7·7	−50·3	−53·7	Definition poor.
	24	M	2	F	+ 7·9	−49·6	−30·7	Star-line seen with difficulty.
	28	N	2	F	+ 8·3	−34·2	−34·2	
Nov.	6	M	2	F	+ 8·9	−43·4	−29·5	Star-line fairly well defined.
	7	N	2	F	+ 9·0	−34·4	−34·2	Spectrum faint and unsteady.
					ε Cygni.			
Sept.	25	M	2	b_1	+ 7·2	−11·0	−20·5	Definition bad.
	27	M	2	b_1	+ 7·5	− 2·8	+ 2·6	Spectrum unsteady.
Oct.	22	M	2	F	+10·9	+15·4	+22·2	Star-line very faint.
					a Cephei.			
July	17	M	1	F	− 6·2	−26·0	−21·8	Measure made with extreme difficulty.
Aug.	19	M	3	F	− 4·5	−30·7	−39·5	Star-line difficult to bisect.

Date. 1884.		Obs.	No. of Meas.	Line.	Earth's Motion in M. per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
Sept.	11	N	2	F	− 2·4	−57·0	−56·6	
	12	M	2	F	− 2·3	−18·3	−18·3	Star-line difficult to bisect.
	20	M	2	F	− 1·5	−40·0	−33·8	Star-line fairly well defined.
Oct.	22	M	2	F	+ 2·1	−29·9	−38·0	
Nov.	6	M	2	F	+ 3·7	−58·2	−36·5	Star-line faint.
						ε Pegasi.		
Sept.	20	M	2	F	+ 8·0	+17·2	+17·7	Definition fair.
	25	M	4	b_1	+ 9·2	−17·9	−16·8	
	27	M	2	b_1	+ 9·8	−29·0	−27·5	Measures very difficult.
Oct.	22	M	2	F	+14·9	−26·3	−25·9	Star spectrum and line faint.
						ζ Pegasi.		
Aug.	22	M	2	F	− 4·2	−11·7	−11·0	Measures very difficult.
Sept.	10	M	2	F	+ 1·2	−14·9	−18·0	Measures considered satisfactory.
	12	M	2	F	+ 1·8	−34·3	−29·1	Definition fair.
	20	M	2	F	+ 4·1	+ 2·0	+ 0·8	Measures very rough.
						Fomalhaut.		
Sept.	12	M	2	F	+ 5·3	+26·6	+25·5	Definition very bad.
						β Pegasi.		
Sept.	27	M	4	b_1	+ 2·1	+15·6	+16·5	Star-lines seen with great difficulty.
						α Pegasi.		
Aug.	5	M	2	F	−10·3	−24·0	−26·6	Measures considered rough.
	12	N	2	F	− 8·7	+ 3·6	+ 5·2	Star-line broad and ill-defined.
	22	M	2	F	− 6·2	−34·3	−30·2	Definition good.
	23	N	2	F	− 6·0	−22·6	−22·4	Measures very difficult.
	25	M	2	F	− 5·4	−17·1	−13·0	Definition poor.
Sept.	4	M	2	F	− 2·7	−18·3	−19·8	Definition fair.
	10	M	2	F	− 1·0	−23·8	−23·5	Definition good.
	12	M	2	F	− 0·4	+ 2·6	+ 4·5	Spectrum bright and steady.
	17	N	2	F	+ 1·1	−38·8	−39·5	
	18	M	2	F	+ 1·4	−57·8	−42·0	Spectrum faint.
	20	M	4	F	+ 2·0	+ 3·6	+ 2·4	Definition poor.
Oct.	22	M	2	F	+10·8	−52·4	−51·2	Measures considered good.
	24	M	2	F	+11·3	−45·0	−34·1	Star-line seen with difficulty.
	28	N	2	F	+12·2	−44·4	−44·5	Spectrum faint; star-line indistinct.
Nov.	6	M	2	F	+14·1	−11·7	−14·1	Star-line fairly well defined.

Date.	Obs.	No. of Meas.	Line.	Motion Measured.	
				Moon.	
Feb. 2	N	1	F	+ 5·1	Moon in cloud.
6	M	5	F	− 2·3	Coincidence appeared perfect.
11	M	5	F	+ 2·0	
12	N	2	F	− 5·9	Coincidence appeared perfect.
29	N	2	F	− 8·2	Spectrum faint. Sky hazy.
Mar. 10	M	5	F	− 0·2	Lines appeared perfectly coincident.
12	M	2	F	− 2·7	Coincidence very satisfactory.
April 5	N	3	F	− 6·0	Coincidence appeared perfect.
10	M	5	F	+ 4·7	
12	N	2	F	− 2·3	Coincidence appeared perfect.
May 13	N	2	F	− 2·5	Coincidence appeared perfect.
30	M	5	F	− 1·2	Moon spectrum rather faint.
June 2	M	5	F	− 2·6	Moon spectrum rather faint.
July 12	N	2	F	− 4·1	Coincidence appeared perfect.
Aug. 5	M	5	F	− 1·8	Coincidence appeared perfect.
7	M	3	F	− 1·7	Coincidence appeared perfect.
11	M	5	F	+ 0·8	Coincidence appeared perfect.
12	N	2	F	− 9·1	Nearly coincident.
14	N	1	F	− 4·0	
Sept. 1	N	2	F	− 2·0	Coincidence appeared perfect.
2	M	5	F	− 1·4	No want of coincidence detected.
4	M	5	F	− 0·7	Coincidence appeared exact.
10	M	5	F	− 5·6	No want of coincidence detected.
11	N	4	F	− 0·7	Coincidence appeared perfect.
27	M	5	b_1	+ 8·9	Moon-lines very faint.
Oct. 28	N	2	F	− 6·1	Nearly coincident.
Nov. 7	N	4	F	− 1·0	
				Sky.	
Jan. 28	M	5	F	+ 1·9	Coincidence appeared perfect.
29	M	4	F	+ 3·0	No want of coincidence detected.
Feb. 16	M	5	F	+ 2·2	Coincidence appeared perfect.
June 27	N	2	F	− 5·9	Coincidence appeared perfect.
Aug. 22	N	2	F	− 4·9	Coincidence appeared perfect.
26	M	5	F	+ 2·8	
Sept. 19	M	5	F	− 0·3	No want of coincidence could be detected.
22	M	5	F	+ 0·1	
Nov. 7	M	5	F	− 2·2	No want of coincidence detected.

Date. 1884.	Obs.	No. of Meas.	Line	Earth's Motion in M per sec.	Concluded Motion of Star. Meas.	Estimd.	Remarks.
					Venus.		
Feb. 21	M	2	F		−23·2	−33·6	Measures not considered satisfactory. Computed motion −6·4
29	N	2	F		−49·5	−45·7	Sky hazy. Computed motion −6·8.
Mar. 24	M	4	b_1		−43·2	−34·1	Displacement clearly towards the *blue*. Computed motion −7·6.
					Mars.		
Mar. 15	M	2	F		+17·3	+13·4	Computed motion +8·1.
24	M	2	b_1		+12·6	+20·5	Spectrum bright and steady; lines well seen. Computed motion +8·8.
					Orion Nebula.		
Feb. 15	M	4	F	+15·0	−33·5	−31·0	Measures merely experimental.
18	M	4	F	+15·3	−51·5		No estimations made. Measures most difficult.

Rotation of Jupiter.

Displacement between the *p* and *f* limbs.

Feb. 6	M	5	F		+33·5		F line in Jupiter not well seen. Slit $0^{in}\cdot0018 = 1''\cdot8$. The slit was placed as nearly on the limb as practicable.
Mar. 24	M	4	b_1		+16·4		Spectrum faint and lines indistinct. Slit $0^{in}\cdot0015 = 1''\cdot5$. The point observed was about 2″ from the limb.

Computed relative motion of the limbs 30·9 miles per second, the equatorial diameter of *Jupiter* being taken as 88,000 miles, and its period of rotation as $9^h\ 56^m$.

Note on the Nautical Almanac Dimensions of the Saturnian System. By Capt. W. Noble.

For many years I have been in the habit of cutting out stencil plates of latten brass to facilitate the sketching of the various planets by thus previously preparing their outlines. I have been recently struck, however, with the discrepancy between the observed proportions of the system of *Saturn* and his rings as seen in the telescope and those derived from diagrams carefully prepared from the data given in the *Nautical Almanac.* To illustrate what I mean I subjoin two sketches, one made at the

telescope on Saturday night last (March 7), the other drawn accurately from the *Nautical Almanac* data. It will be seen at a glance that the latter drawing shows the ball of the planet notably smaller than it appears in the telescope. The most striking illustration of this is seen in the case of the interval between Cassini's division and the south pole of the planet. In reality *Saturn's* south pole just touches this division. In the diagram laid down to scale a very notable gap exists between them. What is wrong in the data I leave others to determine.

Forest Lodge, Maresfield, Uckfield:
1885, *March* 12.

Report of the Royal Observatory, Edinburgh.

Appendix.—Since the publication of the Annual Report, the Government have authorised the Astronomer Royal for Scotland to proceed forthwith in the printing of the Edinburgh Star Catalogue. All the remaining MSS. have therefore been sent to Messrs. Neill & Co. for printing, and it is confidently expected that within the next two years this important Star Catalogue will be in the hands of astronomers.

Note on the Transit of Jupiter's Satellite IV., seen at Clapham, 1885, February 27. By Edmund J. Spitta.

The transit of Satellite IV. was observed here both with the 10-inch Calver Reflector and the $3\frac{1}{8}$-inch Tully Refractor, as well as the continual interruption from clouds would permit. Actual ingress was not seen, but at 9.45, during a wave of fine definition and entire absence of cumuli, the satellite appeared in transit perfectly black and round, projected on the edge of a large white spot without the confines of the neighbouring belt, which spot preceded the satellite. At 10.20, during another fair time, the satellite was seen again, intensely black but decidedly oval, with the longer axis parallel to the belts. The Refractor did not show the blackness as well as the Reflector, but possibly the difference in aperture was sufficient to account for this. On using the occulting eyepiece no perceptible change in the blackness or position of the longer axis was noticeable, and clouds prevented verifying the oval appearance in the Refractor. The Reflector was used on the west side of the polar axis, and the Refractor was a zodiacal Equatorial.

	Sat.	Phenomena.	G.M.T.	Corr. of N.A.	Observer.	Remarks.
			h m s	m s		
1884, Jan. 20	2	Oc. R. First seen	8 35 19·9		S. J. P.	Fair.
		Bisection	36 25·7			
		External contact	39 15·0			
31	1	Tr. E. Internal contact	10 50 11·0		W. C.	Planet very tremulous.
		Bisection	52 21·0			
		External contact	54 51·3			
Feb. 2	3	Oc. D. External contact	10 55 21·4		J. R.	Good.
		Bisection	59 47·9			
		Last seen	11 3 23·4			
22	1	Oc. D. External contact	10 54 8·7		W. C.	Fair.
		Bisection	55 23·2			
		Last seen	56 41·2			
24	1	Ec. R. First seen	8 28 57·1	−0 12·9	W. C.	Good.
		Half light	30 9·6			
		Full light	31 32·6			
Mar. 15	2	Tr. E. Internal contact	7 58 37·3		S. J. P.	Thin clouds passing.
		Bisection	8 1 33·5			
		External contact	3 17·0			
16	1	Oc. D. External contact	10 46 11·6		W. C.	Planet very unsteady.
		Bisection	48 6·6			

	Sat.	Phenomena.	M.T.	Corr. of N.A.	Observer.	Remarks.
			h m s	m s		
1884, Mar. 16		Last seen	49 58·5			
	3	Oc. R. First seen	11 15 25·0		W. C.	Somewhat unsteady.
		Bisection	17 15·5			
		External contact	19 23·5			
	3	Ec. D. Fading	12 20 12·5		W. C.	Good.
		Half light	23 19·0			
		Last seen	26 26·5	+2 19·5		
	1	Ec. R. First seen	14 15 10·2	+0 29·2	W. C.	Hazy.
		Half light	16 26·0			
		Full light	17 35·5			
21	4	Ec. R. First seen	8 18 12·5	−4 6·5	W. C.	Very good.
		Half light	21 45·0			
		Full light	25 41·0			
23	1	Oc. D. External contact	12 38 50·3		W. C.	Very good.
		Bisection	39 45·4			Satellite smaller than usual.
		Last seen	41 38·3			
Ap. 7	2	Oc. D. External contact	7 41 51·1		W. C.	Fair.
		Bisection	43 25·6			
		Last seen	45 4·4			
9	1	Tr. I. External contact	8 14 17·3		S. J. P.	Very unsteady.
		Bisection	16 43·1			
		Internal contact	18 38·4			

	Sat.	Phenomena.	G.M.T.	Corr. of N.A.	Observer.	Remarks.
			h m s	m s		
1884, Ap 9	1	Tr. E. Internal contact	10 31 23·1		W. C.	Very unsteady.
		Bisection	33 53·6			
		External contact	35 40·1			
10	3	Tr. I. External contact	9 10 6·9		W. C.	Hazy.
		Bisection	14 27·7			
		Internal contact	18 38·2			
17	1	Ec. R. First seen	10 54 42·8	+0 37·8	J. R.	Very good.
		Half light	56 44·8			
		Full light	58 21·8			
May 18	1	Tr. E. Internal contact	9 11 53·2		W. C.	Unsteady.
		Bisection	13 54·7			
		External contact	16 17·2			
26	1	Ec. R. First seen	9 29 48·4	+0 46·4	W. C.	Rather hazy.
		Half light	30 43·9			
		Full light	31 26·4			
Nov. 9	1	Tr. E. Internal contact	16 34 19·7		W. C.	Fair.
		Bisection	35 52·7			
		External contact	37 34·2			
10	4	Ec. D. Half light	16 12 17·2		W. C.	Thin clouds passing.
		Last seen	14 20·6	+1 2·6		

The 8-inch Equatorial was used throughout, the observers being the Rev. S. J. Perry, and Messrs. W. Carlisle and J. Rooney.

Occultations of Stars by the Moon.

	Star.	Phen.	G.M.T.	Limb.	Obs.	Remarks.
1883.			h m s			
Mar. 12	*o* Arietis	D.	6 45 19·7	Dark	W.C.	Observation very good.
		R.	7 46 4·6	Bright	„	„
1884.						
Mar. 11	*ν* Leonis	D.	9 23 53·4	Bright	„	Hazy.
		R.	10 21 1·7	„	„	Very good.
Oct. 9	130 Tauri	R.	10 39 12·0	Dark	„	„
12	60 Cancri	D.	16 54 52·0	Bright	„	„
		R.	17 35 1·3	Dark	„	„
	α Cancri	D.	18 0 53·1	Bright	„	Good.
		R.	18 57 3·9	Dark	„	Difficult. Twilight.
Nov. 9	*h* Leonis	D.	13 59 55·8	Bright	„	Very good.
		R.	15 4 9·1	Dark	„	„

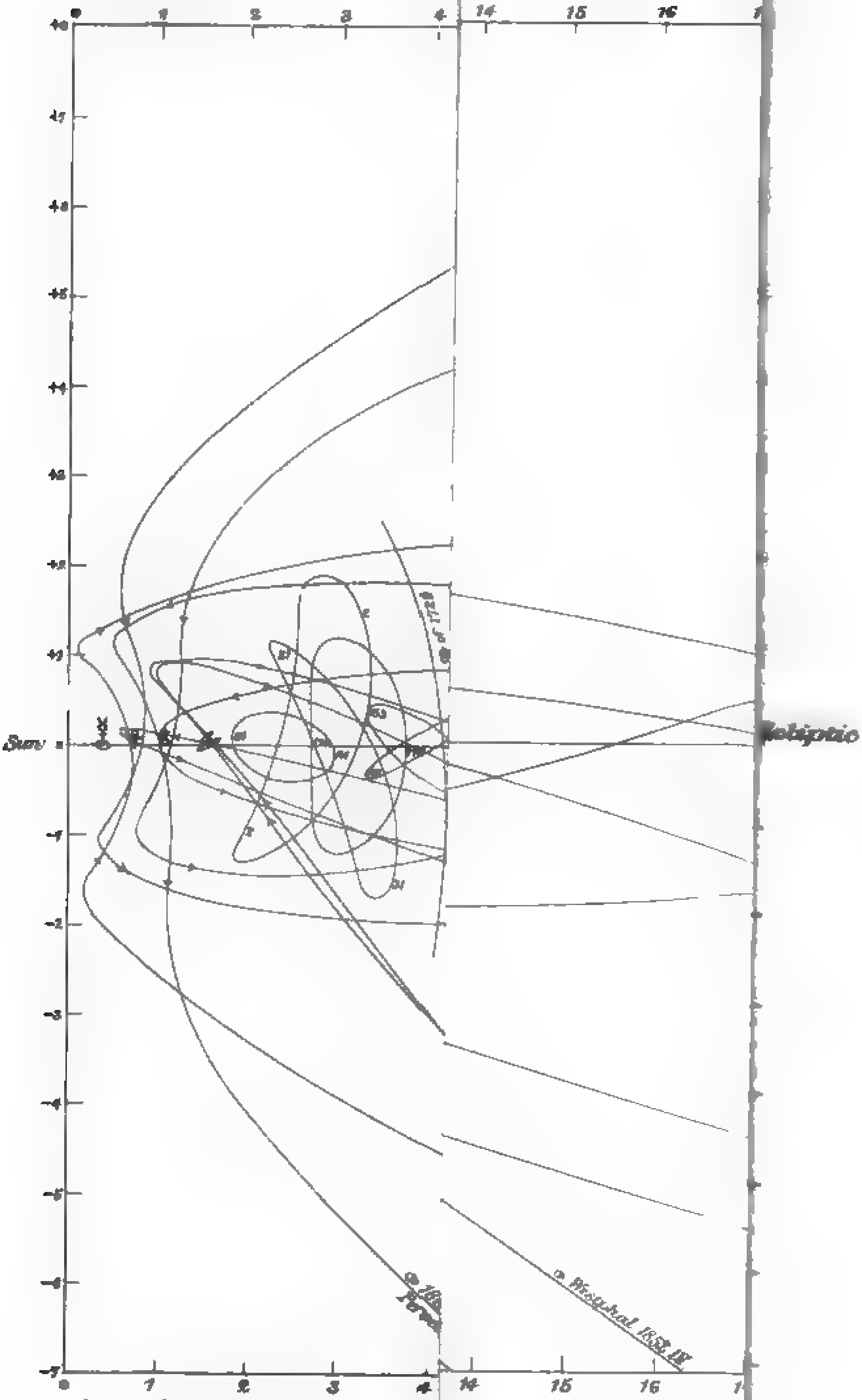
Data for a Graphical Representation of the Solar System. By A. Marth.

The recognition of the chief peculiarities of the orbits of comets and planets, of some of their mutual relations, and especially of their proximities, may be considerably aided by a proper graphical representation. The method of representation, which I have employed in special cases for a long time past, appears to me so serviceable and instructive, that I have thought it worth the trouble to apply it to a great number of orbits, and as some recent publications* seem to show that the method is not known, it will probably be of real service to others if I publish the data, which will enable them to prepare such an instructive representation on an adequate scale for themselves.

The principle of the method employed is very simple. The Sun's centre being the common focus of all the orbits, a plane passing through the Sun's centre perpendicular to the ecliptic will intersect all the orbits. Let this plane rotate, and let, for each orbit, the tracing be represented which the point of intersection produces on the plane in the course of a full rotation, and which, for the present purpose, may perhaps be called the "ecliptical intersect" of the orbit. The form or shape of the tracing or intersect depends on the elements, i, e, ω, of the orbit: i, the inclination to the ecliptic; e, the eccentricity; and ω, the angular distance or departure of the perihelion from the

* *Vide* the dissertation of Andreas Galle, *Zur Berechnung der Proximitäten der Asteroiden-Bahnen*, Breslau, 1883, and the review of it, by Fr. Deichmüller in the *Vierteljahrsschrift der Astron. Gesellschaft*, vol. xix, pp. 214–225.

Monthly Notices of Royal Astronomic



& C° lith. London

ascending node ☊. A circular orbit in the plane of the ecliptic would accordingly be represented by a point or dot, an eccentric orbit in the same plane by a line or dash, a circular orbit inclined to the ecliptic by a circular arc, an eccentric orbit in which ω is $= \pm 90^\circ$ by an arc of another curve. In order to lay down the "ecliptical intersect" of any actual orbit the co-ordinates of a sufficient number of points must be known, through which the curve may be easily drawn by hand. The co-ordinates required are the curtate distances from the Sun and the distances from the plane of the ecliptic, or $r \cos b$ and $r \sin b$, if r denotes the radius-vector and b the latitude, to which must be added the corresponding ecliptical longitudes l and also the true anomalies v. In the present paper I furnish these data for 150 of the minor planets; in a continuation I will communicate similar data for the periodical and a number of other comets. If the graphical representation is intended to serve in the investigations of close proximities, it must be made on an adequate scale, say of 5 inches for the distance 1, and if it is intended to serve in the investigations of such questions as those suggested by the non-appearance of Biela's or De Vico's comet of short period, it must be extended to all the minor planets, and can therefore only be accomplished by being spread over a series of sheets. As the greatest distance from the plane of the ecliptic, which any planet can reach, is

$$+1{\cdot}896 \text{ in the case of } \textit{Pallas},$$

and

$$-1{\cdot}671 \text{ in the case of } \textit{Euphrosyne},$$

the width of the sheets need not extend much beyond these limits; for the parts of cometary orbits outside of these limits will better be represented specially on a smaller scale. This smaller scale will also be sufficient for all the orbits or parts of orbits beyond that of *Saturn*.

The rectangular co-ordinates $r \cos b = x$, and $r \sin b = z$ being reckoned from the Sun's centre, the Sun's surface is to be represented by a circle or semicircle of radius ·0047, the intersect of the Earth by a line extending from 0·9832 to 1·0168 of the x axis, which represents the plane of the ecliptic. The co-ordinates of the points of the ecliptical intersects of *Mercury*, *Venus*, *Mars*, and *Jupiter*, which correspond to the ecliptical longitudes l, are:

	Mercury.		*Venus.*		*Mars.*		*Jupiter.*	
l	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$
0°	0·3515	−0·0315	0·7253	−0·0417	1·393	− ·034	4·955	−0·112
30	·3240	−0·0116	·7235	·0307	1·436	−0·015	4·958	·106
60	·3093	+0·0086	·7215	−0·0115	1·501	+0·010	5·022	·072
90	·3081	·0259	·7194	+0·0106	1·575	·034	5·132	−0·018

	Mercury.		*Venus.*		*Mars.*		*Jupiter.*	
l	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$	$r \cos b$	$r \sin b$
120°	0·3211	0·0377	0·7179	0·0298	1·637	0·050	5·263	+0·043
150	·3487	·0417	·7175	·0410	1·665	·053	5·379	·096
180	·3889	·0349	·7190	·0413	1·648	·040	5·447	·123
210	·4326	+0·0155	·7218	·0306	1·593	+0·016	5·443	·116
240	·4622	−0·0129	·7249	+0·0116	1·520	−0·010	5·370	·077
270	·4591	·0385	·7270	−0·0107	1·450	·031	5·250	+0·024
300	·4314	·0507	·7276	·0302	1·401	·043	5·119	−0·042
330	·3898	·0466	·7268	·0415	1·381	·044	5·013	·089
0	0·3515	−0·0315	0·7253	−0·0417	1·393	−0·034	4·955	−0·112

For the minor planets and comets the values of l, $r \cos b$ and $r \sin b$ are given which correspond to the true anomalies v. The 150 minor planets in the list are (1) to (138), with the exception of (99), (131), and (132), which have been observed in a single apparition only, and the following 15 : (143), (147), (148), (153), (154), (158), (164), (173), (176), (179), (181), (185), (186), (190), and (207). Of these (66), (104), (125), (137), (147), (153), (176), (186), (190), and (207) have been observed in four apparitions, and (164) *Eva*—which is of special interest, as it reaches the smallest curtate distance of all—in only three; all the others have been observed in at least five apparitions. Though for a number of the minor planets I have supplanted my older computations so that the data may be founded upon the latest elements of the orbits, I have not considered it necessary to do so throughout. The data for (41), (43), (71), (76), (80), depend on the elements published in the *Berlin. Astron. Jahrbuch* for 1885, those for (5), (6), (10), (11), (14), (16), (17), (19), (25), (28), (30), (33), (87), (107), (122), (153) in the *Jahrbuch* for 1884, those for (31) in that for 1880. The data of (1) to (4) are founded upon the elements given in the *Nautical Almanac* for 1885; all the others upon those given in the *Berlin. Jahrbuch* for 1886. The longitudes l are all reckoned from the point of the equinox of 1880·0. The magnitudes attached to the names of the planets are the values of g in the Berlin list of elements, and furnish some plausible indication of the relative size of the minor planets. If Δ is the distance of the planet from the Earth and r its distance from the Sun, the apparent magnitude of the planet will be approximately $= g + 5\ (\log \Delta + \log r)$.

	(1) *Ceres* $4^{m}\cdot0$.			(4) *Vesta* $4^{m}\cdot0$.			(5) *Astræa* $6^{m}\cdot9$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
0°	147°·62	2·509	+0·432	251°·97	2·147	+0·140	134°·68	2·090	−0·023
30	178·10	2·528	·470	281·79	2·175	+0·008	164·56	2·134	+0·078
60	208·45	2·615	·388	311·59	2·239	−0·132	194·53	2·264	·169
90	238·33	2·742	+0·196	341·57	2·330	·248	224·62	2·474	·229
120	267·85	2·862	−0·066	11·76	2·433	·305	254·74	2·734	·234
150	297·50	2·934	·329	41·96	2·523	·278	284·77	2·967	·165
180	327·62	2·943	·507	71·97	2·565	·168	314·68	3·064	+0·034
210	358·10	2·903	·540	101·79	2·538	−0·009	344·56	2·969	−0·109
240	28·45	2·832	·420	131·59	2·447	+0·145	14·53	2·737	·204
270	58·33	2·742	−0·196	161·57	2·330	·248	44·62	2·474	·229
300	87·85	2·643	+0·061	191·76	2·226	·279	74·74	2·262	·194
330	117·50	2·556	·287	221·96	2·162	·238	104·77	2·132	·119
0	147·62	2·509	+0·432	251·97	2·147	+0·140	134·68	2·090	−0·023

	(2) *Pallas* $4^{m}\cdot5$.			(3) *Juno* $5^{m}\cdot5$.			(6) *Hebe* $5^{m}\cdot8$.		
0	127·70	1·931	−0·946	54·76	1·943	−0·405	14·56	1·890	−0·413
15	142·24	2·042	0·717	70·07	1·945	·443	29·87	1·887	·472
30	155·54	2·163	0·442	35·46	1·989	·459	45·34	1·914	·505
45	168·10	2·276	−0·126	100·82	2·063	·448	60·84	1·970	·509
60	180·45	2·371	+0·222	116·04	2·172	·410	76·24	2·057	·482
75	193·15	2·441	0·592	131·07	2·314	·341	91·41	2·170	·421
90	206·73	2·488	0·966	145·91	2·482	·240	106·33	2·304	·326
105	221·65	2·522	1·319	160·60	2·668	−0·107	121·02	2·447	·196
120	238·14	2·566	1·619	175·22	2·859	+0·053	135·56	2·588	−0·037
135	255·91	2·650	1·824	189·87	3·036	·232	150·07	2·712	+0·141
150	274·11	2·790	1·896	204·64	3·178	·412	164·68	2·803	·324
165	291·61	2·974	1·805	219·60	3·276	·572	179·50	2·850	·492
180	307·70	3·158	1·548	234·76	3·281	·684	194·56	2·850	·623
195	322·24	3·282	1·153	250·07	3·243	·738	209·87	2·806	·701
210	335·54	3·305	0·675	265·46	3·122	·720	225·34	2·728	·719
225	348·10	3·212	+0·178	280·82	2·976	·646	240·84	2·629	·679
240	0·45	3·021	−0·283	296·04	2·810	·530	256·24	2·520	·590
255	13·15	2·766	0·671	311·07	2·642	·389	271·41	2·410	·468
270	26·73	2·488	0·966	325·91	2·482	·240	286·33	2·304	·326
285	41·65	2·226	1·164	340·60	2·337	+0·094	301·02	2·203	·176
300	58·14	2·014	1·270	355·22	2·210	−0·041	315·56	2·112	+0·030
315	75·91	1·878	1·293	9·87	2·105	·161	330·07	2·032	−0·106
330	94·11	1·826	1·241	24·64	2·024	·262	344·68	1·966	·228
345	111·61	1·850	1·123	39·60	1·965	·343	359·50	1·917	·331
0	127·70	1·931	−0·946	54·76	1·943	−0·405	14·56	1·890	−0·413

v	(8) *Flora* $6^m{\cdot}8$. l	$r\cos b$	$r\sin b$	(9) *Metis* $6^m{\cdot}3$. l	$r\cos b$	$r\sin b$	•(10) *Hygieia* 5^m4. l	$r\cos b$	$r\sin b$
°	°			°			°		
0	33·42	1·846	−0·186	71·35	2·092	+0·009	237·09	2·771	−0·138
30	63·64	1·878	·142	101·24	2·121	·111	267·07	2·806	−0·060
60	93·44	1·990	−0·061	131·25	2·206	·192	297·00	2·925	+0·038
90	123·29	2·147	+0·048	161·38	2·339	·229	326·97	3·092	·136
120	153·20	2·324	·162	191·49	2·496	·206	356·99	3·277	·207
150	183·27	2·473	·243	221·48	2·629	+0·118	27·05	3·432	·224
180	213·42	2·534	·255	251·35	2·681	−0·012	57·09	3·495	·174
210	243·64	2·472	·188	281·24	2·628	·138	87·07	3·438	+0·073
240	273·44	2·329	+0·071	311·25	2·495	·217	117·00	3·284	−0·043
270	303·29	2·147	−0·048	341·38	2·339	·229	146·97	3·092	·136
300	333·20	1·986	·138	11·49	2·206	·182	176·99	2·919	·184
330	3·27	1·879	·185	41·48	2·121	−0·096	207·05	2·800	·183
0	33·42	1·846	−0·186	71·35	2·092	+0·099	237·09	2·771	−0·138

v	(7) *Iris* $5^m{\cdot}8$. l	$r\cos b$	$r\sin b$	(12) *Victoria* $7^m{\cdot}2$. l	$r\cos b$	$r\sin b$	(13) *Egeria* $6^m{\cdot}7$. l	$r\cos b$	$r\sin b$
0	41·94	1·832	+0·109	301·91	1·807	+0·243	120·04	2·260	+0·652
15	56·90	1·846	·070	317·05	1·815	·264	135·67	2·261	·671
30	71·85	1·882	+0·026	332·21	1·848	·271	151·27	2·288	·647
45	86·78	1·942	−0·021	347·35	1·906	·262	166·68	2·337	·582
60	101·72	2·024	·071	2·44	1·989	·236	181·79	2·404	·476
75	116·68	2·128	·121	17·44	2·094	·193	196·57	2·478	·335
90	131·68	2·253	·169	32·37	2·218	·131	211·11	2·552	+0·164
105	146·71	2·393	·210	47·24	2·355	+0·053	225·50	2·616	−0·026
120	161·77	2·542	·241	62·08	2·495	−0·039	239·92	2·664	·222
135	176·84	2·688	·256	76·94	2·626	·138	254·51	2·694	·411
150	191·90	2·812	·250	91·85	2·732	·236	269·38	2·705	·576
165	206·94	2·899	·222	106·84	2·800	·320	284·57	2·702	·702
180	221·94	2·932	·174	121·91	2·820	·379	300·04	2·691	·777
195	236·90	2·905	·110	137·05	2·789	·406	315·67	2·676	·794
210	251·85	2·823	−0·039	152·21	2·713	·398	331·27	2·661	·753
225	266·78	2·700	+0·030	167·35	2·605	·358	346·68	2·644	·658
240	281·72	2·552	·090	182·44	2·478	·294	1·79	2·622	·519
255	296·68	2·399	·136	197·44	2·346	·216	16·57	2·593	·350
270	311·68	2·253	·169	212·37	2·218	·131	31·11	2·552	−0·164
285	326·71	2·124	·186	227·24	2·103	−0·048	45·50	2·500	+0·024
300	341·77	2·016	·191	242·08	2·003	+0·031	59·92	2·442	·204
315	356·84	1·933	·184	256·94	1·922	·101	74·51	2·381	·363
330	11·90	1·883	·167	271·85	1·861	·160	89·38	2·326	·495
345	26·94	1·842	·141	286·84	1·823	·208	104·57	2·283	·593
0	41·94	1·832	+0·109	301·91	1·807	+0·243	120·04	2·260	+0·652

v	(11) *Parthenope* $6^m \cdot 5$. l	$r \cos b$	$r \sin b$	(14) *Irene* $6^m \cdot 6$. l	$r \cos b$	$r \sin b$	(15) *Eunomia* $5^m \cdot 4$. l	$r \cos b$	$r \sin b$
0°	318°·14	2·212	−0·040	179°·42	2·141	+0·344	28°·31	2·104	+0·436
30	348·09	2·236	·123	209·72	2·190	·296	58·79	2·164	·370
60	18·13	2·309	·178	239·69	2·326	+0·170	88·70	2·323	+0·208
90	48·22	2·422	·191	269·36	2·521	−0·018	118·14	2·551	−0·036
120	78·27	2·551	·151	299·06	2·734	·235	147·67	2·796	·320
150	108·23	2·656	−0·063	329·09	2·905	·414	177·75	2·993	·557
180	138·14	2·695	+0·049	359·42	2·972	·477	208·31	3·073	·637
210	168·09	2·652	·146	29·72	2·908	·392	238·79	3·001	·514
240	198·13	2·548	·197	59·69	2·737	−0·200	268·70	2·803	−0·251
270	228·22	2·422	·191	89·36	2·521	+0·018	298·14	2·551	+0·036
300	258·27	2·312	·136	119·06	2·323	·200	327·67	2·317	·265
330	288·23	2·238	+0·053	149·09	2·188	·312	357·75	2·158	·401
0	318·14	2·212	−0·040	179·42	2·141	+0·344	28·31	2·104	+0·436

v	(16) *Psyche* $5^m \cdot 9$. l	$r \cos b$	$r \sin b$	(17) *Thetis* $7^m \cdot 3$. l	$r \cos b$	$r \sin b$	(19) *Fortuna* $7^m \cdot 1$. l	$r \cos b$	$r \sin b$
0	13·84	2·513	−0·092	262·37	2·152	+0·144	30·81	2·056	+0·000
30	43·86	2·553	·131	292·29	2·188	+0·048	60·80	2·094	−0·028
60	73·90	2·674	·140	322·15	2·285	−0·065	90·80	2·206	·051
90	103·92	2·861	·112	352·09	2·433	·174	120·81	2·380	·064
120	133·90	3·077	−0·047	22·17	2·590	·243	150·82	2·585	·061
150	163·86	3·254	+0·040	52·31	2·728	·256	180·82	2·759	·038
180	193·84	3·323	·122	82·37	2·788	·186	210·81	2·829	−0·001
210	223·86	3·251	·167	112·29	2·739	−0·060	240·80	2·759	+0·037
240	253·90	3·073	·160	142·15	2·600	+0·074	270·80	2·585	·060
270	283·92	2·861	·112	172·09	2·433	·174	300·81	2·380	·064
300	313·90	2·678	+0·041	202·17	2·276	·218	330·82	2·206	·052
330	343·86	2·556	−0·032	232·31	2·179	·204	0·82	2·094	·029
0	13·84	2·513	−0·092	262·37	2·152	+0·144	30·81	2·056	+0·000

v	(20) *Massalia* $6^m \cdot 5$. l	$r \cos b$	$r \sin b$	(21) *Lutetia* $7^m \cdot 4$. l	$r \cos b$	$r \sin b$	(24) *Themis* $6^m \cdot 7$. l	$r \cos b$	$r \sin b$
0	100·06	2·062	−0·024	327·41	2·038	−0·101	144·02	2·728	+0·036
30	130·06	2·097	·023	357·44	2·077	·111	174·02	2·770	·026
60	160·06	2·200	·019	27·48	2·192	·095	204·02	2·893	+0·008
90	190·06	2·359	−0·008	57·47	2·371	−0·051	234·02	3·080	−0·014
120	220·06	2·541	+0·007	87·43	2·581	+0·016	264·02	3·292	·035
150	250·06	2·694	·022	117·40	2·757	·089	294·02	3·467	·048
180	280·06	2·754	·032	147·41	2·827	·140	324·02	3·536	·047
210	310·06	2·694	·031	177·44	2·755	·148	354·02	3·467	·032
240	340·06	2·541	·022	207·48	2·578	·112	24·02	3·292	−0·009
270	10·06	2·359	+0·008	237·47	2·371	+0·051	54·02	3·080	+0·014
300	40·06	2·200	−0·006	267·43	2·194	−0·014	84·02	2·893	·030
330	70·06	2·097	·017	297·40	2·078	·067	114·02	2·770	·038
0	100·06	2·062	−0·024	327·41	2·038	−0·101	144·02	2·728	+0·036

♈	(18) *Melpomene* $6^m\cdot9$. l	$r\cos b$	$r\sin b$	(22) *Kalliope* $6^m\cdot1$. l	$r\cos b$	$r\sin b$	(23) *Thalia* $7^m\cdot3$. l	$r\cos b$	$r\sin b$
0°	15°00	1·782	−0·224	58°61	2·605	−0·088	122°84	1·998	+0·296
15	30·13	1·786	·276	73·19	2·613	+0·074	137·98	2·004	·341
30	45·23	1·817	·314	87·81	2·629	·233	153·20	2·039	·367
45	60·46	1·865	·334	102·59	2·652	·382	168·44	2·105	·373
60	75·68	1·943	·336	117·57	2·688	·511	183·63	2·201	·357
75	90·85	2·046	·316	132·77	2·733	·612	198·72	2·326	·317
90	105·91	2·170	·272	148·14	2·796	·676	213·70	2·476	·250
105	120·85	2·308	·204	163·58	2·872	·697	228·56	2·642	·157
120	135·68	2·451	−0·112	178·96	2·959	·669	243·34	2·814	+0·039
135	150·46	2·585	·000	194·18	3·047	·590	258·11	2·974	−0·097
150	165·23	2·692	+0·123	209·19	3·126	·464	272·91	3·104	·238
165	180·07	2·758	·244	223·98	3·183	·299	287·82	3·185	·370
180	195·00	2·773	·349	238·61	3·207	+0·108	302·84	3·204	·474
195	210·13	2·737	·423	253·19	3·195	−0·091	317·98	3·161	·537
210	225·23	2·655	·459	267·81	3·148	·279	333·20	3·064	·551
225	240·46	2·544	·456	282·59	3·072	·442	348·44	2·930	·520
240	255·68	2·418	·418	297·57	2·980	·567	3·63	2·778	·451
255	270·85	2·290	·354	312·77	2·884	·646	18·72	2·623	·357
270	285·91	2·170	·272	328·14	2·796	·676	33·70	2·476	·250
285	300·85	2·062	·182	343·58	2·722	·661	48·56	2·343	·139
300	315·68	1·970	+0·090	358·96	2·667	·603	63·34	2·230	−0·031
315	330·46	1·895	·000	14·18	2·631	·509	78·11	2·137	+0·069
330	345·23	1·842	−0·084	29·19	2·611	·387	92·91	2·066	·159
345	0·07	1·800	·159	43·98	2·603	·244	107·82	2·019	·235
0	15·00	1·782	−0·224	58·61	2·605	−0·088	122·84	1·998	+0·296

♈	(26) *Proserpina* $7^m\cdot3$. l	$r\cos b$	$r\sin b$	(27) *Euterpe* $7^m\cdot2$. l	$r\cos b$	$r\sin b$	(29) *Amphitrite* $6^m\cdot1$. l	$r\cos b$	$r\sin b$
0	236·77	2·424	−0·028	88·13	1·938	−0·005	56·38	2·354	+0·218
30	266·73	2·448	·100	118·12	1·978	+0·022	86·52	2·373	·254
60	296·75	2·521	·149	148·12	2·093	·047	116·66	2·439	·227
90	326·81	2·631	·163	178·13	2·275	·063	146·67	2·537	·137
120	356·85	2·753	·131	208·14	2·492	·063	176·53	2·638	+0·001
150	26·83	2·851	−0·060	238·14	2·680	·044	206·38	2·711	−0·143
180	56·77	2·888	+0·033	268·13	2·756	+0·008	236·38	2·732	·253
210	86·73	2·849	·116	298·12	2·680	−0·030	266·52	2·700	·289
240	116·75	2·751	·163	328·12	2·493	·056	296·66	2·627	·244
270	146·81	2·631	·163	358·13	2·275	·063	326·67	2·537	·137
300	176·85	2·523	·120	28·14	2·093	·053	356·53	2·450	−0·001
330	206·83	2·450	+0·051	58·14	1·971	·032	26·38	2·384	+0·126
0	236·77	2·424	−0·028	88·13	1·938	−0·005	56·38	2·354	+0·218

	(25) *Phocæa* $7^{m}\cdot 9$.			(28) *Bellona* $6^{m}\cdot 6$.			(31) *Euphrosyne* $6^{m}\cdot 8$.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	302°·55	1·660	+0·657	124°·15	2·361	−0·136	90°·50	2·251	+0·960
15	318·64	1·679	0·643	138·97	2·375	−0·039	106·74	2·218	1·068
30	334·44	1·737	0·594	153·78	2·406	+0·063	123·43	2·245	1·118
45	349·74	1·830	0·507	168·61	2·453	·164	140·06	2·337	1·104
60	4·49	1·951	0·382	183·52	2·515	·260	156·13	2·491	1·022
75	18·76	2·091	0·220	198·53	2·593	·345	171·38	2·693	0·866
90	32·77	2·242	+0·022	213·64	2·686	·413	185·80	2·917	0·633
105	46·75	2·392	−0·206	228·82	2·789	·457	199·59	3·158	+0·327
120	60·95	2·531	0·451	244·02	2·898	·471	213·06	3·367	−0·043
135	75·59	2·648	0·693	259·19	3·004	·450	226·57	3·523	0·454
150	90·77	2·734	0·903	274·28	3·095	·393	240·47	3·605	0·868
165	106·49	2·786	1·050	289·26	3·160	·301	255·06	3·607	1·236
180	122·55	2·801	1·108	304·15	3·188	·184	270·50	3·541	1·511
195	138·64	2·780	1·065	318·97	3·174	+0·052	286·74	3·435	1·654
210	154·44	2·725	0·931	333·78	3·119	−0·082	303·43	3·319	1·652
225	169·74	2·637	0·731	348·61	3·030	·203	320·06	3·212	1·517
240	184·49	2·523	0·494	3·52	2·920	·302	336·13	3·115	1·278
255	198·76	2·388	0·251	18·53	2·802	·373	351·38	3·023	0·972
270	212·77	2·242	−0·022	33·64	2·686	·413	5·80	2·917	0·633
285	226·75	2·095	+0·180	48·82	2·582	·423	19·59	2·814	−0·291
300	240·95	1·957	0·349	64·02	2·496	·406	33·06	2·692	+0·035
315	255·59	1·837	0·481	79·19	2·431	·364	46·57	2·564	0·330
330	270·77	1·743	0·576	94·28	2·388	·303	60·47	2·438	0·587
345	286·49	1·682	0·634	109·26	2·365	·226	75·06	2·329	0·798
0	302·55	1·660	+0·657	124·15	2·361	−0·136	90·50	2·251	+0·960

	(30) *Urania* $7^{m}\cdot 4$.			(32) *Pomona* $7^{m}\cdot 5$.			(34) *Circe* $8^{m}\cdot 2$.		
0	31·61	2·053	+0·075	193·82	2·370	−0·104	150·97	2·387	−0·126
30	61·63	2·086	·070	223·70	2·397	+0·011	180·86	2·422	−0·015
60	91·63	2·182	·047	253·59	2·464	·127	210·74	2·513	+0·106
90	121·62	2·328	+0·009	283·60	2·560	·218	240·73	2·644	·210
120	151·60	2·493	−0·037	313·72	2·668	·256	270·83	2·794	·266
150	181·60	2·629	·078	343·83	2·759	·223	300·95	2·921	·250
180	211·61	2·683	·098	13·82	2·799	+0·123	330·97	2·976	·158
210	241·63	2·629	·088	43·70	2·768	−0·012	0·86	2·931	+0·018
240	271·63	2·504	·054	73·59	2·677	·138	30·74	2·804	−0·118
270	301·62	2·328	−0·009	103·60	2·560	·218	60·73	2·644	·210
300	331·60	2·183	+0·032	133·72	2·456	·235	90·83	2·503	·239
330	1·60	2·087	·062	163·83	2·389	·193	120·95	2·414	·207
0	31·61	2·053	+0·075	193·82	2·370	−0·104	150·97	2·387	−0·126

	(33) *Polyhymnia* $8^{m}\cdot2$.			(35) *Leukothea* $8^{m}\cdot3$.			(36) *Atalante* $8^{m}\cdot6$.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	342°·28	1·892	−0·029	201°·38	2·314	−0·144	41°·33	1·868	+0·423
15	357·27	1·909	−0·013	216·31	2·323	·218	56·48	1·857	0·528
30	12·26	1·959	+0·004	231·33	2·361	·281	72·02	1·881	0·608
45	27·25	2·044	·021	246·42	2·428	·330	87·80	1·946	0·659
60	42·25	2·166	·040	261·56	2·527	·363	103·61	2·059	0·676
75	57·25	2·329	·059	276·72	2·657	·376	119·21	2·220	0·652
90	72·25	2·533	·076	291·84	2·817	·365	134·44	2·426	0·580
105	87·26	2·776	·092	306·90	2·998	·325	149·25	2·668	0·453
120	102·26	3·049	·103	321·88	3·189	·256	163·71	2·927	0·268
135	117·27	3·330	·107	336·79	3·373	·158	177·96	3·173	+0·026
150	132·28	3·584	·102	351·65	3·526	−0·036	192·19	3·370	−0·253
165	147·28	3·765	·085	6·50	3·626	+0·098	206·60	3·482	0·539
180	162·28	3·831	·059	21·38	3·656	·228	221·33	3·487	0·789
195	177·27	3·766	+0·026	36·31	3·612	·339	236·48	3·389	0·964
210	192·26	3·586	−0·007	51·33	3·502	·417	252·02	3·216	1·039
225	207·25	3·332	·035	66·42	3·346	·455	267·80	3·005	1·017
240	222·25	3·050	·056	81·56	3·167	·455	283·61	2·792	0·916
255	237·25	2·776	·070	96·72	2·986	·423	299·21	2·596	0·763
270	252·25	2·533	·076	111·84	2·817	·365	314·44	2·426	0·580
285	267·26	2·328	·077	126·90	2·668	·290	329·25	2·281	0·388
300	282·26	2·166	·073	141·88	2·545	·204	343·71	2·158	0·197
315	297·27	2·043	·066	156.79	2·448	·115	357·96	2·055	−0·017
330	312·28	1·958	·055	171·65	2·377	+0·024	12·19	1·971	+0·148
344	327·28	1·909	·043	186·50	2·333	−0·063	26·60	1·908	0·295
0	342·28	1·892	−0·029	201·38	2·314	−0·144	41·33	1·868	+0·423

	(37) *Fides* $7^{m}\cdot2$.			(38) *Leda* $8^{m}\cdot0$.			(40) *Harmonia* $6^{m}\cdot9$.		
0	65·88	2·170	+0·100	100·38	2·314	+0·078	1·13	2·146	−0·161
30	95·91	2·213	·120	130·17	2·357	−0·069	31·22	2·170	·144
60	125·92	2·346	·113	160·05	2·473	·209	61·21	2·214	·089
90	155·95	2·557	·074	190·15	2·657	·312	91·15	2·262	−0·008
120	185·92	2·807	+0·006	220·37	2·879	·341	121·07	2·315	+0·079
150	215·88	3·022	−0·076	250·48	3·077	·270	151·07	2·353	·148
180	245·88	3·107	·143	280·38	3·163	−0·106	181·13	2·366	·176
210	275·91	3·018	·164	310·17	3·087	+0·090	211·22	2·353	·156
240	305·92	2·804	·135	340·05	2·888	·244	241·21	2·314	·093
270	335·95	2·557	·074	10·15	2·657	·312	271·15	2·262	+0·008
300	5·92	2·349	−0·005	40·37	2·465	·292	301·07	2·215	−0·076
330	35·88	2·216	+0·056	70·48	2·349	·206	331·07	2·170	·136
0	65·28	2·170	+0·100	100·38	2·314	+0·078	1·13	2·146	−0·161

	(39) *Laetitia* $6^{\mathrm{m}}{\cdot}0$.			(41) *Daphne* $7^{\mathrm{m}}{\cdot}0$.			(42) *Isis* $7^{\mathrm{m}}{\cdot}7$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
°	°			°			°		
0	2·76	2·444	−0·192	219·72	2·000	+0·373	317·98	1·876	−0·221
15	17·66	2·443	·290	234·80	1·994	·471	333·07	1·883	·264
30	32·69	2·453	·369	250·16	2·021	·546	348·22	1·916	·287
45	47·83	2·491	·430	265·71	2·085	·593	3·39	1·975	·295
60	63·06	2·542	·464	281·30	2·190	·609	18·53	2·062	·285
75	78·30	2·612	·469	296·75	2·336	·588	33·61	2·193	·258
90	93·50	2·696	·442	311·94	2·521	·524	48·60	2·307	·205
105	108·59	2·789	·383	326·84	2·734	·412	63·51	2·456	·134
120	123·56	2·883	·292	341·48	2·965	·251	78·36	2·610	−0·044
135	138·42	2·967	·175	355·94	3·170	+0·045	93·20	2·755	+0·061
150	153·19	3·032	−0·039	10·38	3·338	−0·191	108·06	2·873	·171
165	167·95	3·069	+0·104	24·93	3·436	·432	122·98	2·948	·275
180	182·76	3·075	·242	39·72	3·446	·644	137·98	2·969	·358
195	197·66	3·049	·361	54·80	3·370	·797	153·07	2·933	·411
210	212·69	2·998	·451	70·16	3·228	·872	168·22	2·846	·426
225	227·83	2·929	·505	85·71	3·049	·868	183·39	2·725	·406
240	243·06	2·850	·520	101·30	2·860	·796	198·53	2·586	·357
255	258·30	2·771	·497	116·75	2·681	·675	213·61	2·443	·287
270	273·50	2·696	·442	131·94	2·521	·524	228·60	2·307	·205
285	288·59	2·629	·361	146·84	2·382	·359	243·51	2·185	·120
300	303·56	2·571	·261	161·48	2·270	·192	258·36	2·081	+0·035
315	318·42	2·523	·149	175·94	2·167	−0·031	273·20	1·997	−0·044
330	333·19	2·480	+0·032	190·38	2·090	+0·120	288·06	1·934	·115
345	347·95	2·459	−0·083	204·93	2·033	·255	302·98	1·893	·177
0	2·76	2·444	−0·192	219·72	2·000	+0·373	317·98	1·876	−0·221

	(43) *Ariadne* $7^{\mathrm{m}}{\cdot}9$.			(44) *Nysa* $7^{\mathrm{m}}{\cdot}1$.			(45) *Eugenia* $7^{\mathrm{m}}{\cdot}3$.		
0	278·23	1·832	+0·026	111·70	2·054	−0·044	232·20	2·483	+0·285
30	308·20	1·866	·078	141·64	2·091	+0·025	262·38	2·511	·264
60	338·22	1·971	·115	171·61	2·198	·092	292·41	2·591	·174
90	8·27	2·137	·126	201·63	2·362	·144	322·27	2·702	+0·031
120	38·30	2·335	·102	231·69	2·556	·163	352·09	2·814	−0·133
150	68·28	2·505	+0·043	261·73	2·722	·134	22·05	2·895	·271
180	98·23	2·573	−0·037	291·70	2·790	+0·060	52·20	2·923	·336
210	128·20	2·503	·105	321·64	2·725	−0·032	82·38	2·891	·304
240	158·22	2·333	·136	351·61	2·559	·108	112·41	2·811	·189
270	188·27	2·137	·126	21·63	2·362	·144	142·27	2·702	−0·031
300	218·30	1·972	·086	51·69	2·195	·140	172·09	2·594	+0·123
330	248·28	1·868	−0·025	81·73	2·089	·103	202·05	2·514	·235
0	278·23	1·832	+0·026	111·70	2·054	−0·044	232·20	2·483	+0·285

	(46) *Hestia* $7^m \cdot 7$.			(47) *Aglaja* $7^m \cdot 5$.			(48) *Doris* $6^m \cdot 8$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
0°	356°·39	2·105	+0·010	314°·86	2·503	−0·165	71°·23	2·900	−0·303
30	26·37	2·146	−0·034	344·82	2·547	−0·073	101·41	2·921	·331
60	56·36	2·266	·072	14·71	2·662	+0·044	131·55	2·994	·274
90	86·38	2·453	·098	44·64	2·831	·162	161·50	3·099	−0·140
120	116·40	2·676	·099	74·68	3·023	·250	191·33	3·205	+0·041
150	146·41	2·867	·069	104·79	3·185	·274	221·19	3·277	·221
180	176·39	2·944	−0·014	134·86	3·254	·215	251·23	3·297	·345
210	206·37	2·867	+0·045	164·82	3·196	+0·091	281·41	3·264	·370
240	236·36	2·676	·086	194·71	3·033	−0·050	311·55	3·192	·292
270	266·38	2·453	·098	224·64	2·831	·162	341·50	3·099	+0·140
300	296·40	2·265	·083	254·68	2·653	·219	1·33	3·006	−0·038
330	326·41	2·146	·052	284·79	2·538	·218	41·19	2·933	·198
0	356·39	2·105	+0·010	314·86	2·503	−0·165	71·23	2·900	−0·303

	(49) *Pales* $7^m \cdot 0$.			(50) *Virginia* $8^m \cdot 5$.			(51) *Nemausa* $7^m \cdot 3$.		
0	31·32	2·376	+0·128	9·91	1·896	−0·026	174·39	2·208	−0·009
30	61·35	2·439	·101	39·89	1·953	·069	204·01	2·219	+0·184
60	91·33	2·625	+0·047	69·91	2·130	·102	233·99	2·254	·336
90	121·29	2·928	−0·030	99·94	2·434	·114	264·35	2·320	·407
120	151·26	3·307	·118	129·96	2·839	·096	294·74	2·408	·329
150	181·28	3·653	·189	159·94	3·232	−0·037	324·76	2·489	·225
180	211·32	3·799	·204	189·91	3·405	+0·047	354·39	2·523	+0·010
210	241·35	3·655	·151	219·89	3·230	·114	24·01	2·490	−0·207
240	271·33	3·309	−0·061	249·91	2·837	·135	53·99	2·410	·359
270	301·29	2·928	+0·030	279·94	2·434	·114	84·35	2·320	·407
300	331·26	2·624	·094	309·96	2·132	·072	114·74	2·253	·345
330	1·28	2·438	·126	339·94	1·954	+0·023	144·76	2·217	·200
0	31·32	2·376	+0·128	9·91	1·896	−0·026	174·39	2·208	−0·009

	(52) *Europa* $6^m \cdot 2$.			(53) *Kalypso* $8^m \cdot 4$.			(55) *Pandora* $7^m \cdot 4$.		
0	107·22	2·745	−0·137	92·75	2·074	−0·145	12·29	2·356	+0·006
30	136·99	2·786	+0·047	122·71	2·127	−0·069	42·10	2·392	·157
60	166·82	2·886	·228	152·60	2·273	+0·031	72·11	2·502	·278
90	196·88	3·035	·366	182·52	2·504	·140	102·31	2·681	·340
120	227·11	3·212	·416	212·56	2·785	·232	132·51	2·899	·313
150	257·28	3·368	·348	242·67	3·040	·269	162·49	3·090	+0·186
180	287·22	3·439	+0·171	272·75	3·150	·220	192·29	3·167	−0·008
210	316·99	3·385	−0·057	302·71	3·050	+0·099	222·10	3·089	·203
240	346·82	3·228	·255	332·60	2·795	−0·038	252·11	2·898	·322
270	16·88	3·035	·366	2·52	2·504	·140	283·31	2·681	·340
300	47·11	2·871	·372	32·56	2·265	·189	312·51	2·503	·270
330	77·28	2·772	·287	62·67	2·120	·187	342·49	2·393	−0·144
0	107·22	2·745	−0·137	92·75	2·074	−0·145	12·29	2·356	+0·006

	(54) *Alexandra* $7^{m}\cdot6$.			(56) *Melete* $8^{m}\cdot6$.			(57) *Mnemosyne* $6^{m}\cdot5$.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
°	°			°			°		
0	295·74	2·177	−0·141	294·69	1·968	+0·273	51·90	2·752	−0·397
15	310·45	2·193	−0·027	309·81	1·983	·252	66·80	2·738	·543
30	325·14	2·218	+0·091	324·87	2·027	·217	81·99	2·743	·659
45	339·90	2·282	·209	339·85	2·097	·167	97·40	2·773	·736
60	354·78	2·354	·321	354·76	2·193	·103	112·93	2·832	·769
75	9·82	2·447	·422	9·63	2·313	+0·026	128·43	2·920	·752
90	25·01	2·560	·504	24·49	2·453	−0·062	143·76	3·031	·684
105	40·31	2·692	·559	39·37	2·609	·157	158·83	3·154	·563
120	55·62	2·835	·578	54·31	2·770	·252	173·64	3·277	·394
135	70·87	2·979	·552	69·32	2·925	·339	188·23	3·383	−0·186
150	85·98	3·107	·479	84·41	3·056	·406	202·72	3·458	+0·047
165	100·94	3·199	·362	99·54	3·146	·442	217·23	3·492	·283
180	115·74	3·240	·209	114·69	3·179	·441	231·90	3·483	·502
195	130·45	3·219	+0·039	129·81	3·151	·400	246·80	3·436	·682
210	145·14	3·141	−0·128	144·87	3·065	·328	261·99	3·362	·807
225	159·90	3·017	·276	159·85	2·935	·233	277·40	3·274	·869
240	174·78	2·867	·391	174·76	2·778	·130	292·93	3·185	·864
255	189·82	2·709	·467	189·63	2·613	−0·029	308·43	3·103	·799
270	205·01	2·560	·504	204·49	2·453	+0·062	323·76	3·031	·684
285	220·31	2·431	·505	219·37	2·309	·139	338·83	2·968	·530
300	235·62	2·328	·474	234·31	2·187	·199	353·64	2·914	·350
315	250·87	2·253	·418	249·32	2·090	·242	8·23	2·865	+0·157
330	265·98	2·204	·340	264·41	2·021	·268	22·72	2·820	−0·038
345	280·94	2·180	·246	279·54	1·980	·278	37·23	2·782	·225
0	295·74	2·177	−0·141	294·69	1·968	+0·273	51·90	2·752	−0·397

	(58) *Concordia* $8^{m}\cdot3$.			(59) *Elpis* $7^{m}\cdot6$.			(67) *Echo* $8^{m}\cdot5$.		
0	189·29	2·583	+0·106	18·25	2·389	−0·168	99·23	1·952	−0·122
30	219·28	2·593	·193	48·23	2·409	·309	129·28	1·994	·111
60	249·37	2·629	·231	78·50	2·499	·379	159·28	2·118	·071
90	279·47	2·687	·209	108·79	2·652	·354	189·24	2·314	−0·007
120	309·48	2·751	·129	138·81	2·833	·226	219·19	2·546	+0·073
150	339·39	2·799	+0·009	168·54	2·978	−0·016	249·18	2·746	·145
180	9·29	2·813	−0·115	198·25	3·024	+0·213	279·23	2·827	·177
210	39·28	2·791	·208	228·23	2·954	·378	309·28	2·746	·153
240	69·37	2·743	·241	258·50	2·810	·426	339·28	2·546	·086
270	99·47	2·687	·209	288·79	2·652	·354	9·24	2·314	+0·007
300	129·48	2·636	·123	318·81	2·520	·201	39·19	2·119	−0·061
330	159·39	2·600	−0·009	348·54	2·429	+0·013	69·18	1·994	·105
0	189·29	2·583	+0·106	18·25	2·389	−0·168	99·23	1·952	−0·122

	(62) *Erato* 8^{m}·2.			(63) *Ausonia* 7^{m}·3			(64) *Angelina* 7^{m}·2.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	39°·00	2·574	−0·099	271°·06	2·086	−0·194	124°·37	2·348	+0·006
30	69·01	2·627	·085	301·09	2·123	·129	154·36	2·383	−0·022
60	99·01	2·783	−0·048	330·99	2·218	−0·027	184·36	2·485	·046
90	128·99	3·028	+0·007	0·84	2·356	+0·093	214·36	2·640	·061
120	158·97	3·318	·070	30·81	2·508	·203	244·37	2·815	·060
150	188·98	3·569	·123	60·92	2·632	·265	274·37	2·959	·041
180	219·00	3·670	·141	91·06	2·685	·250	304·37	3·016	−0·008
210	249·01	3·569	·115	121·09	2·641	·160	334·36	2·960	+0·027
240	279·01	3·319	+0·058	150·99	2·516	+0·031	4·36	2·815	·052
270	308·99	3·028	−0·007	180·84	2·356	−0·093	34·36	2·640	·061
300	338·97	2·783	·059	210·81	2·211	·179	64·37	2·485	·053
330	8·98	2·627	·090	240·92	2·116	·213	94·37	2·383	·033
0	39·00	2·574	−0·099	271·06	2·086	−0·194	124·37	2·348	+0·006

	(65) *Cybele* 6^{m}·4.			(66) *Maja* 9^{m}·0.			(67) *Asia* 8^{m}·5.		
0	261·14	3·051	+0·182	47·24	2·177	+0·074	306·52	1·955	+0·199
30	291·17	3·094	·139	77·26	2·219	·112	336·61	2·003	·151
60	321·14	3·214	+0·059	107·30	2·351	·125	6·53	2·134	+0·062
90	351·09	3·390	−0·044	137·33	2·560	·107	36·38	2·334	−0·058
120	21·06	3·583	·147	167·31	2·809	+0·054	66·29	2·570	·186
150	51·08	3·738	·217	197·27	3·024	−0·025	96·37	2·792	·279
180	81·14	3·799	·226	227·24	3·109	·106	126·52	2·860	·291
210	111·17	3·740	·168	257·26	3·021	·152	156·61	2·781	·210
240	141·14	3·585	−0·066	287·30	2·806	·150	186·53	2·576	−0·075
270	171·09	3·390	+0·044	317·33	2·560	·107	216·38	2·334	+0·058
300	201·06	3·212	·132	347·31	2·354	−0·046	246·29	2·129	·154
330	231·08	3·092	·179	17·27	2·222	+0·019	276·37	1·998	·201
0	261·14	3·051	+0·182	47·24	2·177	+0·074	306·52	1·955	+0·199

	(68) *Leto* 7^{m}·0.			(69) *Hesperia* 6^{m}·8.			(72) *Feronia* 8^{m}·9.		
0	346·18	2·252	−0·269	108·58	2·447	−0·357	308·13	1·986	+0·185
30	16·17	2·312	−0·155	138·78	2·507	·279	338·21	2·019	·146
60	45·92	2·460	+0·006	168·65	2·663	−0·126	8·16	2·107	+0·067
90	75·69	2·681	·192	198·34	2·892	+0·083	38·04	2·234	−0·037
120	105·70	2·940	·359	228·15	3·147	·307	67·96	2·372	·144
150	135·94	3·170	·443	258·27	3·360	·473	98·00	2·483	·221
180	166·18	3·275	·391	288·58	3·450	·503	128·13	2·527	·230
210	196·17	3·194	+0·215	318·78	3·372	·375	158·21	2·486	·179
240	225·92	2·962	−0·008	348·65	3·159	+0·149	188·16	2·375	−0·076
270	255·69	2·681	·192	18·34	2·892	−0·083	218·04	2·234	+0·037
300	285·70	2·442	·298	48·15	2·654	·259	247·96	2·104	·128
330	315·94	2·295	·321	78·27	2·497	·352	278·80	2·016	·179
0	346·18	2·252	−0·269	108·58	2·447	−0·357	308·13	1·986	+0·185

	(61) *Danaë* 7m·1.			(70) *Panopæa* 7m·8.			(71) *Niobe* 7m·3.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
° 0	° 343·56	2·488	+0·141	° 300·31	2·101	−0·412	° 221·79	2·087	−0·895
15	357·89	2·477	·344	315·60	2·108	·430	238·09	2·104	0·886
30	12·53	2·481	·530	330·91	2·143	·430	254·11	2·166	0·823
45	27·58	2·503	·691	346·14	2·205	·400	269·57	2·266	0·709
60	43·05	2·551	·817	1·25	2·293	·344	284·37	2·393	0·543
75	58·81	2·632	·899	16·19	2·401	·261	298·61	2·532	0·330
90	74·65	2·748	·927	30·99	2·524	·153	312·48	2·669	−0·075
105	90·33	2·896	·891	45·70	2·653	−0·022	326·28	2·789	+0·209
120	105·67	3·063	·786	60·40	2·778	+0·122	340·29	2·883	0·505
135	120·57	3·227	·611	75·17	2·888	·271	354·76	2·944	0·789
150	135·09	3·364	·375	90·06	2·972	·409	9·86	2·975	1·030
165	149·37	3·450	+0·097	105·11	3·021	·522	25·60	2·983	1·201
180	163·56	3·474	−0·197	120·31	3·031	·594	41·79	2·976	1·276
195	177·89	3·419	·474	135·60	3·003	·618	58·09	2·963	1·247
210	192·53	3·311	·707	150·91	2·941	·590	74·11	2·943	1·119
225	207·58	3·166	·874	166·14	2·854	·518	89·57	2·909	0·910
240	223·05	3·011	·965	181·25	2·750	·385	104·37	2·854	0·648
255	238·81	2·867	·980	196·19	2·638	·287	118·61	2·773	0·361
270	254·65	2·748	·927	210·99	2·524	·153	132·48	2·669	+0·075
285	270·33	2·658	·818	225·70	2·416	+0·020	146·28	2·546	−0·191
300	285·67	2·595	·666	240·40	2·316	−0·102	160·29	2·417	0·424
315	300·57	2·551	·483	255·17	2·232	·209	174·76	2·294	0·615
330	315·09	2·521	·281	270·06	2·165	·298	189·86	2·190	0·758
345	329·37	2·499	−0·070	285·11	2·121	·366	205·60	2·117	0·852
0	343·56	2·488	+0·141	300·31	2·101	−0·412	221·79	2·087	−0·895

	(73) *Klytia* 8m·8.			(74) *Galatea* 8m·3.			(76) *Freia* 7m·4.		
0	57·44	2·543	+0·082	8·27	2·114	+0·025	90·81	2·833	−0·087
30	87·46	2·557	·106	38·20	2·169	−0·053	120·82	2·888	·103
60	117·48	2·598	·102	68·17	2·341	·126	150·84	3·054	·096
90	147·49	2·658	·072	98·22	2·613	·180	180·84	3·315	·062
120	177·48	2·719	+0·020	128·29	2·900	·195	210·83	3·624	−0·006
150	207·45	2·765	−0·039	158·31	3·299	·147	240·81	3·888	+0·067
180	237·44	2·782	·089	188·27	3·441	−0·040	270·81	3·993	·122
210	267·46	2·763	·114	218·20	3·301	+0·080	300·82	3·886	·139
240	297·48	2·717	·107	248·17	2·970	·160	330·84	3·622	·114
270	327·49	2·658	·072	278·22	2·613	·180	0·84	3·315	·062
300	357·48	2·600	−0·019	308·29	2·334	·153	30·83	3·056	+0·002
330	27·45	2·559	+0·037	338·31	2·168	·097	60·81	2·890	−0·050
0	57·44	2·543	+0·082	8·27	2·114	+0·025	90·81	2·833	−0·087

	(75) *Eurydike* $8^m \cdot 4$.			(78) *Diana* $7^m \cdot 5$.			(80) *Sappho* $8^m \cdot 2$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
° 0	° 335·41	1·852	−0·067	° 122·74	2·053	+0·161	° 355·87	1·827	+0·188
15	350·36	1·868	−0·027	137·62	2·070	·088	10·81	1·843	·130
30	5·31	1·914	+0·016	152·46	2·109	+0·008	25·69	1·877	+0·063
45	20·26	1·989	·061	167·30	2·169	−0·077	40·52	1·931	−0·010
60	35·23	2·097	·106	182·17	2·250	·163	55·36	2·002	·088
75	50·22	2·238	·151	197·12	2·352	·246	70·25	2·088	·167
90	65·25	2·413	·192	212·16	2·473	·321	85·22	2·191	·242
105	80·29	2·619	·226	227·27	2·611	·381	100·27	2·304	·308
120	95·35	2·848	·248	242·43	2·756	·420	115·40	2·423	·358
135	110·40	3·079	·253	257·60	2·900	·429	130·57	2·538	·385
150	125·43	3·286	·234	272·73	3·025	·403	145·73	2·638	·382
165	140·44	3·432	·191	287·78	3·113	·341	160·84	2·709	·347
180	155·41	3·486	·127	302·74	3·151	·248	175·87	2·740	·282
195	170·36	3·437	+0·050	317·62	3·129	·133	190·81	2·725	·192
210	185·31	3·294	−0·027	332·46	3·051	−0·011	205·69	2·664	−0·090
225	200·26	3·088	·094	347·30	2·929	+0·104	220·52	2·567	+0·013
240	215·23	2·855	·145	2·17	2·781	·201	235·36	2·447	·107
255	230·22	2·623	·177	17·12	2·624	·274	250·25	2·317	·185
270	245·25	2·413	·192	32·16	2·473	·321	265·22	2·191	·242
285	260·29	2·235	·193	47·27	2·340	·342	280·27	2·077	·277
300	275·35	2·092	·183	62·43	2·231	·340	295·40	1·982	·293
315	290·40	1·984	·163	77·60	2·147	·318	310·57	1·909	·289
330	305·43	1·909	·136	92·73	2·091	·279	325·73	1·859	·270
345	320·44	1·866	·104	107·78	2·060	·226	340·84	1·832	·235
0	335·41	1·852	−0·067	122·74	2·053	+0·161	355·87	1·827	+0·188

	(77) *Frigga* $7^m \cdot 9$.			(79) *Eurynome* $7^m \cdot 8$.			(82) *Alkmene* $8^m \cdot 3$.		
0	59·03	2·318	+0·084	44·32	1·968	−0·048	131·51	2·145	+0·103
30	89·05	2·354	·101	74·28	2·009	·120	161·53	2·200	·078
60	119·07	2·481	·095	104·34	2·136	·168	191·51	2·363	+0·031
90	149·07	2·623	·061	134·43	2·344	·180	221·47	2·626	−0·033
120	179·05	2·781	+0·006	164·47	2·601	·141	251·45	2·953	·103
150	209·03	2·958	−0·058	194·41	2·827	−0·049	281·47	3·249	·156
180	239·03	3·016	·109	224·32	2·918	+0·071	311·51	3·374	·162
210	269·05	2·956	·127	254·28	2·822	·168	341·53	3·251	·115
240	299·07	2·779	·106	284·34	2·596	·205	11·51	2·954	−0·039
270	329·07	2·623	·061	314·43	2·344	·180	41·47	2·626	+0·033
300	359·05	2·483	−0·005	344·47	2·140	·116	71·45	2·361	·082
330	29·03	2·356	+0·046	14·41	2·012	+0·035	101·47	2·199	·106
0	59·03	2·318	+0·084	44·32	1·968	−0·048	131·51	2·145	+0·103

	(81) *Terpsichore* 8m·2.			(84) *Klio* 8m·8.			(85) *Io* 7m·7.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
°	°			°			°		
0	48·43	2·240	+0·223	339·24	1·806	+0·061	323·60	2·108	+0·384
15	63·47	2·248	·273	354·08	1·813	·134	338·69	2·131	·317
30	78·57	2·284	·308	9·01	1·843	·202	353·61	2·178	·230
45	93·71	2·350	·327	24·04	1·895	·261	8·39	2·246	·125
60	108·85	2·444	·327	39·17	1·973	·309	23·09	2·331	+0·006
75	123·94	2·567	·306	54·35	2·076	·342	37·78	2·432	−0·124
90	138·98	2·714	·261	69·55	2·203	·355	52·55	2·543	·258
105	153·93	2·877	·193	84·71	2·351	·344	67·45	2·662	·387
120	168·83	3·046	+0·102	99·78	2·511	·306	82·53	2·784	·501
135	183·69	3·204	−0·007	114·74	2·667	·237	97·75	2·901	·586
150	198·56	3·333	·126	129·62	2·799	·141	113·06	3·003	·631
165	213·46	3·415	·243	144·43	2·888	+0·024	128·37	3·078	·626
180	228·43	3·438	·343	159·24	2·917	−0·099	143·60	3·116	·568
195	243·47	3·399	·413	174·08	2·880	·214	158·69	3·107	·462
210	258·57	3·306	·446	189·01	2·786	·305	173·61	3·052	·322
225	273·71	3·174	·442	204·04	2·652	·365	188·39	2·955	·165
240	288·85	3·021	·404	219·17	2·499	·391	203·09	2·829	−0·007
255	303·94	2·864	·341	234·35	2·345	·386	217·78	2·687	+0·137
270	318·98	2·714	·261	249·55	2·203	·355	232·55	2·543	·2[illegible]
285	333·93	2·579	·173	264·71	2·081	·305	247·45	2·409	·350
300	348·83	2·465	−0·083	279·78	1·982	·241	262·53	2·295	·413
315	3·69	2·372	+0·005	294·74	1·906	·169	277·75	2·205	·446
330	18·56	2·303	·087	309·62	1·852	·093	293·06	2·144	·451
345	33·46	2·259	·161	324·43	1·818	−0·015	308·37	2·112	·430
0	48·43	2·240	+0·223	339·24	1·806	+0·061	323·60	2·108	+0·384

	(83) *Beatrix* 8m·6.			(86) *Semele* 8m·3.			(88) *Thisbe* 7m·4.		
0	191·13	2·226	+0·055	29·25	2·415	−0·173	309·23	2·321	+0·111
30	221·02	2·250	−0·046	59·24	2·479	−0·099	339·24	2·360	·190
60	250·96	2·312	·139	89·15	2·661	+0·005	9·35	2·486	·228
90	281·01	2·405	·202	119·07	2·949	·128	39·45	2·689	·209
120	311·12	2·510	·213	149·07	3·307	·243	69·44	2·930	+0·127
150	341·18	2·598	·164	179·16	3·632	·304	99·33	3·133	−0·009
180	11·13	2·634	−0·065	209·25	3·772	·270	129·23	3·210	·154
210	41·02	2·602	+0·053	239·24	3·633	+0·146	159·24	3·123	·252
240	70·96	2·515	·151	269·15	3·316	−0·007	189·35	2·920	·267
270	101·01	2·405	·202	299·07	2·949	·128	219·45	2·689	·209
300	131·12	2·308	·196	329·07	2·653	·195	249·44	2·494	−0·108
330	161·18	2·246	·142	359·16	2·472	·207	279·33	2·367	+0·007
0	191·13	2·226	+0·055	29·25	2·415	−0·173	309·23	2·321	+0·111

	(87) *Sylvia* 7^{m}·2.			(89) *Julia* 7^{m}·1.			(92) *Undina* 6^{m}·7.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	334°·65	3·144	−0·596	352°·29	2·054	+0·388	327°·72	2·840	−0·352
15	349·92	3·151	·608	7·37	2·043	·490	342·79	2·838	·431
30	5·18	3·182	·581	22·74	2·058	·565	357·94	2·857	·484
45	20·34	3·235	·516	38·30	2·102	·609	13·17	2·897	·508
60	35·37	3·305	·416	53·91	2·178	·618	28·38	2·958	·499
75	50·26	3·386	·284	69·38	2·283	·587	43·54	3·038	·457
90	65·05	3·470	−0·127	84·59	2·414	·513	58·59	3·129	·382
105	79·78	3·550	+0·046	99·49	2·558	·396	73·53	3·226	·276
120	94·53	3·619	·223	114·12	2·702	·237	88·37	3·318	−0.144
135	109·37	3·673	·391	128·57	2·829	+0·045	103·16	3·397	+0·004
150	124·33	3·718	·536	142·98	2·921	−0·166	117·94	3·453	·158
165	139·43	3·727	·645	157·52	2·965	·375	132·79	3·482	·305
180	154·65	3·727	·707	172·29	2·959	·559	147·72	3·482	·431
195	169·92	3·714	·716	187·37	2·907	·697	162·79	3·456	·524
210	185·18	3·687	·673	202·74	2·821	·774	177·94	3·408	·577
225	200·34	3·648	·582	218·30	2·717	·787	193·17	3·345	·586
240	215·37	3·598	·452	233·91	2·610	·740	208·38	3·275	·553
255	230·26	3·538	·296	249·38	2·507	·644	223·54	3·202	·482
270	245·05	3·470	+0·127	264·59	2·414	·513	238·59	3·129	·382
285	259·78	3·397	−0·044	279·49	2·330	·360	253·53	3·061	·262
300	274·53	3·324	·205	294·12	2·255	·198	268·37	2·997	+0·131
315	289·37	3·257	·347	308·57	2·188	−0·035	283·16	2·941	−0·004
330	304·33	3·208	.463	322·98	2·131	+0·121	297·94	2·894	·133
345	319·43	3·162	·547	337·52	2·085	·264	312·79	2·860	·251
0	334·65	3·144	−0·596	352·29	2·054	+0·388	327·72	2·840	−0·352

	(90) *Antiope* 7^{m}·5.			(91) *Ægina* 8^{m}·2.			(93) *Minerva* 7^{m}·4.		
0	301·19	2·620	−0·080	82·17	2·308	+0·082	274·70	2·346	−0·355
30	331·21	2·671	·104	112·19	2·338	·086	304·99	2·392	·314
60	1·23	2·821	·105	142·20	2·427	·068	334·99	2·520	·191
90	31·24	3·056	·078	172·19	2·559	+0·031	4·71	2·703	−0·003
120	61·22	3·334	−0·023	202·17	2·705	−0·020	44·43	2·896	+0·214
150	91·20	3·570	+0·048	232·16	2·823	·070	64·43	3·046	·396
180	121·19	3·664	·111	262·17	2·868	·101	94·70	3·103	·469
210	151·21	3·567	·140	292·19	2·822	·103	124·99	3·046	·400
240	181·23	3·331	·125	322·20	2·704	·076	154·99	2·896	·220
270	211·24	3·056	·078	352·19	2·559	−0·031	184·71	2·703	+0·003
300	241·22	2·823	+0·020	22·17	2·428	+0·018	214·43	2·520	−0·186
330	271·20	2·673	−0·036	52·16	2·339	·058	244·43	2·392	·311
0	301·19	2·620	−0·080	82·17	2·308	+0·082	274·70	2·346	−0·355

	(95) *Arethusa* $7^m{\cdot}3$.			(96) *Ægle* $7^m{\cdot}4$.			(97) *Klotho* $7^m{\cdot}4$.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
°	°			°			°		
0	34·26	2·608	+0·299	162·57	2·609	−0·253	65·47	1·948	−0·404
15	49·00	2·632	·159	177·23	2·598	·423	80·79	1·963	·402
30	63·64	2·670	+0·006	192·17	2·604	·570	96·05	2·010	·378
45	78·28	2·722	−0·151	207·42	2·632	·686	111·18	2·090	·331
60	93·00	2·786	·307	222·92	2·687	·764	126·15	2·199	·259
75	107·89	2·861	·452	238·52	2·772	·797	140·97	2·337	·163
90	122·98	2·950	·578	254·07	2·886	·778	155·68	2·496	−0·045
105	138·24	3·050	·672	269·40	3·022	·702	170·37	2·672	+0·094
120	153·61	3·159	·724	284·43	3·165	·570	185·11	2·851	·246
135	168·98	3·270	·725	299·17	3·297	·384	199·98	3·020	·399
150	184·26	3·372	·669	313·68	3·400	−0·159	215·00	3·159	·535
165	199·36	3·451	·558	328·10	3·458	+0·089	230·18	3·251	·635
180	214·26	3·494	·400	342·57	3·463	·336	245·47	3·281	·681
195	229·00	3·490	·210	357·23	3·414	·555	260·79	3·245	·665
210	243·64	3·438	−0·008	12·17	3·325	·727	276·05	3·149	·592
225	258·28	3·345	+0·186	27·42	3·212	·837	291·18	3·008	·476
240	273·00	3·222	·355	42·92	3·093	·880	306·15	2·842	·335
255	287·89	3·085	·488	58·52	2·982	·857	320·97	2·667	·187
270	302·98	2·950	·578	74·07	2·886	·778	355·68	2·496	+0·045
285	318·24	2·829	·623	89·40	2·810	·653	350·37	2·341	−0·083
300	333·61	2·732	·626	104·43	2·749	·495	5·11	2·206	·191
315	348·98	2·662	·590	119·17	2·701	·315	19·98	2·097	·277
330	4·26	2·619	·520	133·68	2·662	+0·124	35·00	2·016	·342
345	19·36	2·603	·421	148·10	2·631	−0·068	50·18	1·966	·384
0	34·26	2·608	+0·299	162·57	2·609	−0·253	65·47	1·948	−0·404

	(94) *Aurora* $7^m{\cdot}1$.			(100) *Hekate* $7^m{\cdot}8$.			(103) *Hera* $6^m{\cdot}9$.		
0	49·37	2·887	+0·291	306·45	2·575	+0·008	320·97	2·489	−0·020
30	79·52	2·905	·398	336·30	2·641	−0·139	350·87	2·510	·135
60	109·80	2·989	·408	6·28	2·760	·262	20·89	2·574	·220
90	139·94	3·126	·309	36·43	2·985	·334	51·01	2·673	·252
120	169·79	3·275	+0·115	66·59	3·261	·321	81·11	2·786	·216
150	199·51	3·381	−0·127	96·60	3·504	·205	111·09	2·879	−0·116
180	229·37	3·407	·343	126·45	3·604	−0·012	140·97	2·914	+0·023
210	259·52	3·352	·460	156·30	3·505	+0·185	170·87	2·877	·155
240	289·80	3·247	·443	186·28	3·262	·310	200·89	2·785	·238
270	319·94	3·126	·309	216·43	2·985	·334	231·01	2·673	·252
300	349·79	3·015	−0·106	246·59	2·760	·271	261·11	2·576	·200
330	19·51	2·930	+0·110	276·60	2·621	·153	291·09	2·512	+0·101
0	49·37	2·887	+0·291	306·45	2·575	+0·008	320·97	2·489	−0·020

	(98) *Ianthe* $8^{m}.3$.			(101) *Helena* $7^{m}.6$.			(102) *Miriam* $9^{m}.4$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
° 0	° 149·69	2·155	+0·248	° 328·07	2·223	−0·107	° 354·97	1·986	+0·105
15	164·24	2·179	+0·104	342·85	2·235	−0·005	9·94	2·001	·066
30	178·70	2·217	−0·049	357·62	2·261	+0·098	24·89	2·044	+0·021
45	193·21	2·267	·206	12·45	2·300	·199	39·83	2·113	−0·027
60	207·88	2·332	·360	27·38	2·352	·292	54·78	2·210	·077
75	222·82	2·411	·503	42·43	2·419	·371	69·75	2·335	·128
90	238·04	2·509	·626	57·60	2·498	·431	84·75	2·485	·177
105	253·50	2·625	·717	72·82	2·589	·464	99·79	2·656	·219
120	269·05	2·757	·763	88·05	2·684	·466	114·84	2·840	·251
135	284·56	2·895	·754	103·22	2·778	·433	129·90	3·021	·266
150	299·88	3·025	·682	118·29	2·859	·365	144·95	3·178	·260
165	314·92	3·126	·549	133·23	2·917	·265	159·97	3·288	·229
180	329·69	3·179	·365	148·07	2·941	·141	174·97	3·329	·177
195	344·24	3·171	−0·151	162·85	2·929	+0·007	189·94	3·294	·108
210	358·70	3·101	+0·069	177·62	2·880	−0·125	204·89	3·189	−0·033
225	13·21	2·980	·271	192·45	2·801	·242	219·83	3·033	+0·039
240	27·88	2·827	·437	207·38	2·704	·335	234·78	2·850	·100
255	42·82	2·664	·556	222·43	2·599	·399	249·75	2·661	·146
270	58·04	2·509	·626	237·60	2·498	·431	264·75	2·485	·177
285	73·50	2·376	·649	252·82	2·409	·432	279·79	2·330	·192
300	89·05	2·274	·629	268·05	2·335	·406	294·84	2·203	·195
315	104·56	2·203	·574	283·22	2·281	·356	309·90	2·105	·185
330	119·88	2·163	·488	298·29	2·245	·286	324·95	2·037	·166
345	134·92	2·148	·377	313·23	2·226	·202	339·97	1·997	·139
0	149·69	2·155	+0·248	328·07	2·223	−0·107	354·97	1·986	+0·105

	(104) *Klymene* $8^{m}.0$.			(106) *Dione* $7^{m}.1$.			(108) *Hecuba* $7^{m}.4$.		
0	59·85	2·659	+0·038	26·18	2·603	−0·127	173·51	2·883	−0·004
30	89·84	2·706	·099	56·11	2·659	−0·027	203·44	2·917	·116
60	119·86	2·849	·140	86·02	2·810	+0·088	233·44	3·016	·203
90	149·89	3·076	·149	116·00	3·061	·198	263·51	3·169	·244
120	179·91	3·337	·117	146·06	3·355	·270	293·59	3·343	·220
150	209·89	3·561	+0·043	176·15	3·613	·270	323·58	3·486	−0·129
180	239·85	3·649	−0·052	206·18	3·723	·182	353·51	3·542	+0·005
210	269·84	3·558	·130	236·11	3·623	+0·036	23·44	3·485	·138
240	299·86	3·335	·164	266·02	3·364	−0·106	53·44	3·342	·225
270	329·89	3·076	·149	296·00	3·061	·198	83·51	3·169	·244
300	359·91	2·851	·100	326·06	2·809	·226	113·59	3·017	·199
330	29·89	2·708	−0·032	356·15	2·652	·198	143·58	2·917	+0·108
0	59·85	2·659	+0·038	26·18	2·603	−0·127	173·51	2·883	−0·004

v	(105) *Artemis* 8m·5. l	r cos b	r sin b	(107) *Camilla* 6m·5. l	r cos b	r sin b	(109) *Felicitas* 8m·7. l	r cos b	r sin b
° 0	° 240·80	1·864	+0·586	° 115·47	3·187	−0·485	° 56·62	1·882	+0·209
15	256·39	1·844	·677	130·53	3·207	·401	71·70	1·892	·246
30	272·38	1·856	·729	145·48	3·242	·290	86·82	1·934	·270
45	288·49	1·906	·739	160·33	3·288	·158	101·97	2·010	·280
60	304·39	1·992	·704	175·12	3·342	−0·012	117·10	2·121	·275
75	319·82	2·109	·620	189·90	3·399	+0·140	132·17	2·267	·252
90	334·70	2·247	·487	204·74	3·457	·287	147·17	2·448	·209
105	349·08	2·389	·306	219·67	3·513	·421	162·09	2·658	·142
120	3·14	2·519	+0·082	234·72	3·566	·530	176·97	2·886	+0·053
135	17·10	2·621	−0·164	249·87	3·615	·605	191·82	3·111	−0·056
150	31·23	2·680	·417	265·08	3·658	·638	206·70	3·305	·176
165	45·75	2·693	·650	280·30	3·691	·625	221·63	3·435	·292
180	60·80	2·662	·837	295·47	3·711	·565	236·62	3·476	·387
195	76·39	2·601	·954	310·53	3·714	·464	251·70	3·419	·444
210	92·38	2·525	·992	325·48	3·698	·330	266·82	3·278	·457
225	108·49	2·448	·950	340·33	3·661	·175	281·97	3·081	·430
240	124·39	2·377	·840	355·12	3·606	+0·013	297·10	2·862	·372
255	139·82	2·311	·680	9·90	3·535	−0·145	312·17	2·645	·294
270	154·70	2·247	·487	24·74	3·457	·287	327·17	2·448	·209
285	169·08	2·181	·279	39·67	3·378	·405	342·09	2·278	·122
300	183·14	2·111	−0·071	54·72	3·305	·491	356·97	2·138	−0·039
315	197·10	2·040	+0·127	69·87	3·247	·543	11·82	2·029	+0·037
330	211·23	1·971	·307	85·08	3·206	·559	26·70	1·950	·104
345	225·75	1·909	·461	100·30	3·186	·539	41·63	1·901	·162
0	240·80	1·864	+0·586	115·47	3·187	−0·485	56·62	1·882	+0·209

v	(110) *Lydia* 7m·1. l	r cos b	r sin b	(111) *Ate* 8m·2. l	r cos b	r sin b	(112) *Iphigenia* 8m·8. l	r cos b	r sin b
0	337·22	2·508	−0·259	110·70	2·323	+0·054	338·36	2.119	+0·024
30	7·32	2·538	·204	140·60	2·352	−0·050	8·34	2·151	·069
60	37·27	2·614	−0·093	170·54	2·434	·147	38·35	2·246	·099
90	67·12	2·717	+0·049	200·59	2·556	·213	68·38	2·390	·106
120	97·01	2·820	·190	230·70	2·696	·226	98·40	2·556	·083
150	127·07	2·898	·286	260·76	2·813	·173	128·38	2·693	+0·033
180	157·22	2·930	·303	290·70	2·862	−0·066	158·36	2·747	−0·031
210	187·32	2·903	·233	320·60	2·818	+0·060	188·34	2·692	·086
240	217·27	2·825	+0·101	350·54	2·701	·163	218·35	2·555	·113
270	247·12	2·717	−0·049	20·59	2·556	·213	248·38	2·390	·106
300	277·01	2·610	·176	50·70	2·430	·203	278·40	2·247	·073
330	307·07	2·534	·250	80·76	2·349	·145	308·38	2·152	−0·026
0	337·22	2·508	−0·259	110·70	2·323	+0·054	338·36	2·119	+0·024

	(113) *Amalthea* $8^{m} \cdot 4$.			(114) *Kassandra* $7^{m} \cdot 8$.			(115) *Thyra* $7^{m} \cdot 8$.		
u	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	200°·20	2·161	+0·186	153°·25	2·313	−0·038	43°·08	1·883	+0·385
30	230·31	2·185	·184	183·15	2·350	+0·065	73·55	1·937	·327
60	260·36	2·256	·135	213·11	2·455	·158	103·46	2·083	+0·184
90	290·30	2·357	+0·046	243·17	2·619	·220	132·92	2·292	−0·032
120	320·19	2·464	−0·064	273·27	2·811	·228	162·46	2·521	·284
150	350·14	2·545	·164	303·31	2·975	·167	192·54	2·706	·496
180	20·20	2·573	·221	333·25	3·043	+0·050	223·08	2·782	·568
210	50·31	2·541	·214	3·15	2·979	−0·082	253·55	2·713	·458
240	80·36	2·461	·147	33·11	2·815	·182	283·46	2·527	−0·224
270	110·30	2·357	−0·046	63·17	2·619	·220	312·92	2·292	+0·032
300	140·19	2·259	+0·059	93·27	2·453	·199	342·46	2·078	·234
330	170·14	2·188	·141	123·31	2·347	·132	12·54	1·932	·354
0	200·20	2·161	+0·186	153·25	2·313	−0·038	43·08	1·883	+0·385

	(116) *Sirona* $7^{m} \cdot 3$.			(118) *Peitho* $8^{m} \cdot 1$.			(119) *Althæa* $7^{m} \cdot 5$.		
0	152·69	2·366	+0·148	77·90	2·039	+0·141	12·62	2·367	+0·046
30	182·74	2·408	·133	107·91	2·068	·246	42·48	2·391	−0.077
60	212·74	2·528	·083	138·14	2·177	·297	72·43	2·455	·186
90	242·69	2·709	+0·005	168·37	2·358	·276	102·51	2·551	·252
120	272·64	2·916	−0·086	198·36	2·578	+0·171	132·66	2·662	·254
150	302·64	3·087	·164	228·13	2·761	−0·005	162·71	2·756	·182
180	332·69	3·154	·198	257·90	2·826	·196	192·62	2·795	−0·055
210	2·74	3·087	·170	287·91	2·742	·326	222·48	2·760	+0·089
240	32·74	2·916	·096	318·14	2·560	·350	252·43	2·667	·202
270	62·69	2·709	−0·005	348·37	2·358	·276	282·51	2·551	·252
300	92·64	2·528	+0·075	18·36	2·192	−0·146	312·66	2·450	·234
330	122·64	2·408	·128	48·13	2·083	+0·003	342·71	2·387	·158
0	152·69	2·366	+0·148	77·90	2·039	+0·141	12·62	2·367	+0·046

	(120) *Lachesis* $7^{m} \cdot 6$.			(122) *Gerda* $7^{m} \cdot 2$.			(23) *Brunhild* $8^{m} \cdot 5$.		
0	221·91	2·936	−0·310	204·45	3·084	+0·038	69·57	2·352	+0·226
30	252·09	2·950	·362	234·45	3·100	·072	99·56	2·395	+0·130
60	282·28	3·012	·321	264·46	3·144	·088	129·40	2·500	−0·005
90	312·28	3·104	·192	294·47	3·208	·081	159·25	2·650	·153
120	342·10	3·195	−0·003	324·47	3·276	·052	189·26	2·815	·276
150	11·91	3·255	+0·196	354·46	3·327	+0·007	219·42	2·952	·332
180	41·91	3·268	·345	24·45	3·345	−0·041	249·57	3·013	·290
210	72·09	2·237	·397	54·45	3·326	·077	279·56	2·967	−0·161
240	102·28	3·177	·338	84·46	3·275	·092	309·40	2·828	+0·006
270	132·28	3·104	·192	114·47	3·208	·081	339·25	2·650	·153
300	162·10	3·029	+0·003	144·47	3·145	·050	9·26	2·488	·244
330	191·91	2·967	−0·178	174·46	3·100	−0·006	39·42	2·383	·268
0	221·91	2·936	−0·310	204·45	3·084	+0·038	69·57	2·352	+0·226

	(117) *Lomia* $7^{m}\cdot5$.			(121) *Hermione* $6^{m}\cdot6$.			(129) *Antigone* $6^{m}\cdot6$.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
0°	47°88	2·850	+0·647	357°93	2·995	−0·393	242°38	2·210	+0·457
15	63·23	2·833	·726	13·04	3·010	·361	257·62	2·232	·417
30	78·76	2·832	·755	28·09	3·051	·306	272·71	2·285	·348
45	94·24	2·849	·737	43·08	3·114	·231	287·63	2·366	·255
60	109·61	2·879	·666	58·00	3·196	·138	302·40	2·470	·140
75	124·75	2·920	·551	72·88	3·292	−0·030	317·08	2·594	+0·005
90	139·62	2·963	·396	87·75	3·398	+0·086	331·75	2·733	−0·144
105	154·27	3·000	·212	102·64	3·507	·205	346·51	2·881	·300
120	168·82	3·024	+0·012	117.59	3·614	.316	1·41	3·029	·452
135	183·30	3·032	−0·191	132·60	3·708	·410	16·49	3·168	·584
150	197·93	3·025	·383	147·68	3·783	·478	31·72	3·285	·681
165	212·77	3·007	·549	162·81	3·834	·511	47·16	3·367	·726
180	227·88	2·983	·678	177·93	3·854	·506	62·38	3·403	·709
195	243·23	2·961	·759	193·04	3·840	·460	77·62	3·386	·632
210	258·76	2·946	·787	208·09	3·794	·381	92·71	3·316	·505
225	274·24	2·942	·761	223·08	3·720	·276	107·63	3·203	·345
240	289·61	2·946	·682	238·00	3·624	·156	122·40	3·057	·173
255	304·75	2·955	·557	252·88	3·513	+0·032	137·08	2·896	−0·006
270	319·62	2·963	·396	267·75	3·398	−0·086	151·75	2·733	+0·144
285	334·27	2·964	·210	282·64	3·287	·192	166·81	2·580	·269
300	348·82	2·955	−0·011	297·59	3·186	·278	181·41	2·447	·365
315	3·30	2·937	+0·185	312·60	3·103	·343	196·49	2·340	·432
330	17·93	2·908	·368	327·68	3·042	·384	211·72	2·263	·469
345	32·77	2·877	·526	342·81	3·005	·401	227·16	2·220	·478
0	47·88	2·850	+0·647	357·93	2·995	−0·393	242·38	2·210	+0·457

	(124) *Alkeste* $7^{m}\cdot1$.			(125) *Liberatris* $7^{m}\cdot8$.			(126) *Velleda* $8^{m}\cdot8$.		
0	246·86	2·427	+0·106	275·84	2·523	+0·196	347·94	2·180	−0·065
30	276·89	2·449	·125	305·88	2·551	·142	17·91	2·209	−0·011
60	306·93	2·516	·113	335·83	2·624	+0·050	47·88	2·286	+0·049
90	336·93	2·614	·070	5·74	2·725	−0·062	77·87	2·410	·101
120	6·90	2·720	+0·003	35·69	2·831	·166	107·90	2·544	·130
150	36·86	2·801	−0·069	65·74	2·912	·229	137·93	2·654	·124
180	66·86	2·830	·124	95·84	2·945	·229	167·94	2·698	·080
210	96·89	2·798	·143	125·88	2·917	·162	197·91	2·657	+0·013
240	126·93	2·717	·122	155·83	2·835	−0·054	227·88	2·547	−0·054
270	156·93	2·614	·070	185·74	2·725	+0·062	257·87	2·410	·101
300	186·90	2·519	−0·003	215·69	2·620	·154	287·90	2·288	·117
330	216·86	2·453	+0·060	245·74	2·547	·201	317·93	2·207	·103
0	246·86	2·427	+0·106	275·84	2·523	+0·196	347·94	2·180	−0·065

	(127) *Johanna* $7^{\mathrm{m}}\cdot1$.			(128) *Nemesis* $7^{\mathrm{m}}\cdot2$.			(133) *Cyrene* $7^{\mathrm{m}}\cdot3$.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0°	119°·98	2·545	+0·370	16°·07	2·385	−0·228	247°·03	2·613	−0·319
30	150·25	2·573	·329	46·08	2·430	·135	277·14	2·666	·235
60	180·26	2·652	·202	75·93	2·541	−0·003	307·02	2·803	−0·087
90	210·01	2·745	+0·012	105.78	2·702	+0·145	336·79	3·000	+0·103
120	239·75	2·833	−0·193	135·78	2·879	·272	6·68	3·215	·291
150	269·73	2·892	·357	165·92	3·028	·332	36·80	3·391	·417
180	299·98	2·910	·423	196·07	3·092	·295	67·03	3·465	·423
210	330·25	2·889	·370	226·08	3·041	·169	97·14	3·403	·300
240	0·26	2·831	·215	255·93	2·892	+0·003	127·02	3·226	+0·100
270	30·01	2·745	−0·012	285·78	2·702	−0·145	156·79	3·000	−0·103
300	59·75	2·654	+0·181	315·78	2·530	·239	186·68	2·793	·253
330	89·73	2·574	·318	345·92	2·419	·266	216·80	2·656	·326
0	119·98	2·545	+0·370	16·07	2·385	−0·228	247·03	2·613	−0·319

	(130) *Elektra* $6^{\mathrm{m}}\cdot5$.			(137) *Meliboea* $7^{\mathrm{m}}\cdot4$.			(148) *Gallia* $7^{\mathrm{m}}\cdot5$.		
0	18·46	2·331	−0·783	309·44	2·403	+0·548	34·25	2·064	−0·913
15	34·13	2·303	0·905	324·72	2·430	.493	50·68	2·052	0·969
30	50·26	2·321	0·978	339·81	2·491	·409	67·25	2·092	0·969
45	66·53	2·393	0·996	354·80	2·581	·296	83·47	2·182	0·911
60	82·56	2·520	0·954	9·41	2·696	+0·157	99·01	2·317	0·792
75	98·05	2·695	0·847	24·02	2·832	−0·004	113·76	2·478	0·613
90	112·90	2·903	0·670	38·64	2·982	·182	127·84	2·649	0·375
105	127·20	3·124	0·425	53·36	3·139	·368	141·51	2·809	−0·086
120	141·12	3·330	−0·119	68·25	3·296	·548	155·09	2·939	+0·239
135	154·95	3·497	+0·231	83·36	3·443	·704	168·91	3·024	0·576
150	168·96	3·600	0·596	98·65	3·567	·816	183·27	3·059	0·893
165	183·41	3·627	0·934	114·04	3·656	·866	198·38	3·047	1·155
180	198·46	3·583	1·203	129·44	3·696	·842	214·25	3·003	1·329
195	214·13	3·486	1·370	144·72	3·682	·747	230·68	2·946	1·392
210	230·26	3·362	1·416	159·81	3·611	·593	247·25	2·891	1·340
225	246·53	3·235	1·346	174·80	3·491	·401	263·47	2·841	1·186
240	262·56	3·116	1·180	189·41	3·336	−0·195	279·01	2·790	0·954
255	278·05	3·007	0·945	204·02	3·161	+0·004	293·76	2·728	0·675
270	292·90	2·903	0·670	218·64	2·982	·182	307·84	2·649	0·375
285	307·20	2·799	0·381	233·36	2·813	·330	321·51	2·552	+0·078
300	321·12	2·693	+0·096	248·25	2·665	·443	335·09	2·440	−0·198
315	334·95	2·586	−0·171	263·36	2·545	·520	348·91	2·323	0·442
330	348·96	2·484	0·411	278·65	2·460	·563	3·27	2·213	0·646
345	3·41	2·396	0·617	294·04	2·413	·571	18·38	2·122	0·805
0	18·46	2·331	−0·783	309·44	2·403	+0·548	34·25	2·064	−0·913

	(134) *Sophrosyne* $8^m\cdot1$.			(135) *Hertha* $7^m\cdot8$.			(136) *Austria* $8^m\cdot9$.		
°	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0	66°89	2·218	+0·449	319°82	1·931	−0·032	316°50	2·075	+0·266
30	97·48	2·254	·431	349·80	1·977	+0·008	346·36	2·111	+0·120
60	127·66	2·369	·304	19·78	2·110	·050	15·97	2·157	−0·063
90	157·27	2·527	+0·081	49·79	2·325	·086	45·71	2·257	·242
120	186·69	2·680	−0·192	79·81	2·589	·104	75·84	2·341	·370
150	216·50	2·781	·438	109·83	2·826	·092	106·24	2·417	·401
180	246·89	2·809	·569	139·82	2·924	+0·048	136·50	2·460	·316
210	277·48	2·765	·529	169·80	2·827	−0·012	166·36	2·446	−0·139
240	307·66	2·665	·341	199·78	2·591	·061	195·97	2·369	+0·068
270	337·27	2·527	−0·081	229·79	2·325	·086	225·71	2·257	·242
300	6·69	2·382	+0·170	259·81	2·109	·085	255·84	2·151	·340
330	36 50	2·267	·357	289·83	1·976	·064	286·24	2·086	·346
0	66·89	2·218	+0·449	319·82	1·931	−0·032	316·50	2·075	+0·266

	(153) *Hilda* $7^m\cdot3$.			(154) *Bertha* $7^m\cdot0$.			(164) *Eva* $8^m\cdot3$.		
0	285·53	3·250	+0·380	191·71	2·904	+0·484	0·69	1·571	−0·694
15	300·63	3·260	·432	205·93	2·943	+0·226	16·77	1·612	0·638
30	315·76	3·306	·459	219·96	2·973	−0·050	32·22	1·694	0·546
45	330·90	3·388	·460	234·03	2·991	0·327	46·94	1·811	0·418
60	346·01	3·505	·431	248·38	2·998	0·591	61·05	1·956	0·251
75	1·06	3·653	·373	263·18	3·001	0·824	74·80	2·123	−0·045
90	16·03	3·825	·284	278·51	3·011	1·010	88·49	2·306	+0·200
105	30·94	4·011	·167	294·29	3·037	1·134	102·43	2·497	0·478
120	45·81	4·196	+0·026	310·33	3·087	1·182	116·89	2·691	0·776
135	60·67	4·365	−0·130	326·31	3·161	1·147	132·05	2·877	1·064
150	75·56	4·498	·286	341·95	3·250	1·027	147·91	3·042	1·301
165	90·51	4·580	·427	357·09	3·336	0·829	164·25	3·171	1·437
180	105·53	4·601	·538	11·71	3·398	0·566	180·69	3·242	1·433
195	120·63	4·560	·604	25·93	3·427	−0·263	196·77	3·237	1·281
210	135·76	4·464	·620	39·96	3·407	+0·057	212·22	3·149	1·015
225	150·90	4·327	·587	54·03	3·343	0·366	226·94	2·989	0·689
240	166·01	4·165	·513	68·38	3·244	0·639	241·05	2·778	0·356
255	181·06	3·993	·408	83·18	3·126	0·858	254·80	2·542	+0·054
270	196·03	3·825	·284	98·51	3·011	1·010	268·49	2·306	−0·200
285	210·94	3·668	·152	114·29	2·916	1·089	282·43	2·086	0·399
300	225·81	3·531	−0·022	130·33	2·854	1·093	296·89	1·895	0·546
315	240·67	3·418	+0·101	146·31	2·828	1·026	312·05	1·743	0·645
330	255·56	3·331	·212	161·95	2·835	0·896	327·91	1·636	0·700
345	270·51	3·274	·306	177·09	2·865	0·712	344·25	1·579	0·715
0	285·53	3·250	+0·380	191·71	2·904	+0·484	0·69	1·571	−0·694

	(138) *Tolosa* 9m·1.			(143) *Adria* 9m·0.			(147) *Protogeneia* 8m·4.		
v	l	r cos b	r sin b	l	r cos b	r sin b	l	r cos b	r sin b
°	°			°			°		
0	311·67	2·053	−0·113	221·01	2·518	−0·472	27·21	3·054	+0·070
30	341·72	2·092	·113	251·58	2·534	·510	57·21	3·066	+0·025
60	11·74	2·207	·085	281·98	2·618	·417	87·19	3·095	−0·028
90	41·71	2·387	−0·030	311·82	2.740	−0·207	117·18	3·137	·075
120	71·67	2·596	+0·042	341·27	2·850	+0·076	147·19	3·179	·102
150	101·65	2·772	·114	10·86	2·909	·357	177·21	3·211	·102
180	131·67	2·841	·156	41·01	2·911	·546	207·21	3·224	·074
210	161·72	2·770	·149	71·58	2·874	·578	237·21	3·213	−0·026
240	191·74	2·594	·100	101·98	2·815	·449	267·19	3·180	+0·029
270	221·71	2·387	+0·030	131·82	2·740	+0·207	297·18	3·137	·075
300	251·67	2·209	−0·036	161·27	2·650	−0·071	327·19	3·094	·100
330	281·65	2·093	·086	190·86	2·566	·315	357·21	3·064	·098
0	311·67	2·053	−0·113	221·01	2·518	−0·472	27·21	3·054	+0·070

	(173) *Ino* 7m·6.			(176) *Idunna* 8m·0.			(181) *Eucharis* 7m·0.		
0	12·80	2·143	−0·380	20·85	2·666	+0·007	96·94	2·359	−0·588
15	27·91	2·139	·468	34·75	2·666	−0·259	111·84	2·407	0·440
30	43·24	2·164	·531	48·91	2·668	0·515	126·36	2·478	0·263
45	58·70	2·221	·565	63·56	2·678	0·748	140·65	2·567	−0·062
60	74·15	2·312	·566	78·81	2·707	0·948	154·88	2·669	+0·158
75	89·48	2·436	·531	94·62	2·767	1·100	169·24	2·781	0·388
90	104·59	2·586	·456	110·80	2·867	1·189	183·91	2·904	0·617
105	119·46	2·754	·340	126·98	3·011	1·202	198·98	3·038	0·829
120	134·13	2·923	−0·185	142·82	3·189	1·126	214·44	3·183	1·004
135	148·69	3·075	+0·002	158·10	3·379	0·957	230·19	3·336	1·118
150	163·25	3·191	·206	172·77	3·551	0·701	246·00	3·487	1·150
165	177·92	3·255	·406	186·95	3·671	0·375	261·64	3·615	1·084
180	192·80	3·259	·578	200·85	3·715	−0·009	276·94	3·698	0·921
195	207·91	3·205	·701	214·75	3·673	+0·357	291·84	3·713	0·678
210	223·24	3·106	·762	228·91	3·554	0·685	306·36	3·651	0·387
225	238·70	2·974	·758	243·56	3·383	0·945	320·65	3·517	+0·084
240	254·15	2·845	·696	258·81	3·192	1·118	334·88	3·332	−0·197
255	269·48	2·711	·591	274·62	3·013	1·197	349·24	3·118	0·435
270	284·59	2·586	·456	290·80	2·867	1·189	3·91	2·904	0·617
285	299·46	2·474	·305	306·98	2·766	1·104	18·98	2·709	0·739
300	314·13	2·376	+0·150	322·82	2·705	0·955	34·44	2·549	0·804
315	328·69	2·292	−0·002	338·10	2·676	0·758	50·19	2·434	0·816
330	343·25	2·223	·144	352·77	2·666	0·526	66·00	2·366	0·781
345	357·92	2·173	·271	6·95	2·665	0·272	81·64	2·343	0·703
0	12·80	2·143	−0·380	20·85	2·666	+0·007	96·94	2·359	−0·588

	(158) *Koronis* 8m·7.			(179) *Klytæmnestra* 7m·6.			(207) *Hedda* 9m·5.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
° 0	° 58·83	2·718	+0·032	° 355·22	2·625	+0·352	° 217·02	2·215	−0·021
30	88·83	2·737	+0·010	25·38	2·671	·271	246·97	2·222	·092
60	118·82	2·788	−0·015	55·27	2·784	+0·118	276·99	2·244	·139
90	148·82	2·862	·037	85·01	2·937	−0·082	307·05	2·277	·151
120	178·82	2·939	·050	114·85	3·095	·281	337·10	2·313	·121
150	208·83	2·998	·050	144·96	3·218	·418	7·07	2·342	−0·058
180	238·83	3·021	·035	175·22	3·269	·438	37·02	2·352	+0·022
210	268·83	2·999	−0·011	205·38	3·229	·328	66·97	2·341	·097
240	298·82	2·939	+0·016	235·27	3·105	−0·131	96·99	2·312	·143
270	328·82	2·862	·037	265·01	2·937	+0·082	127·05	2·277	·151
300	358·82	2·788	·047	294·85	2·775	·252	157·10	2·245	·118
330	28·83	2·736	·045	324·96	2·662	·346	187·07	2·223	+0·055
0	58·83	2·718	+0·032	355·22	2·625	+0·352	217·02	2·215	−0·021

	(185) *Eunike* 7m·0.			(186) *Celuta* 8m·9.			(190) *Ismene* 6m·7.		
0	12·68	2·307	−0·622	327·92	1·979	−0·337	105·75	3·285	−0·333
15	27·81	2·265	0·788	342·84	2·002	·246	120·80	3·306	·294
30	43·56	2·250	0·907	357·59	2·039	·139	135·81	3·357	·237
45	59·75	2·271	0·973	12·22	2·087	−0·020	150·78	3·440	·163
60	76·05	2·335	0·980	26·83	2·145	+0·107	165·72	3·551	−0·074
75	92·06	2·439	0·923	41·53	2·210	·234	180·63	3·686	+0·025
90	107·50	2·572	0·799	56·40	2·281	·356	195·55	3·839	·131
105	122·28	2·718	0·610	71·46	2·357	·462	210·50	4·004	·237
120	136·51	2·853	0·364	86·71	2·436	·543	225·49	4·170	·334
135	150·38	2·959	−0·076	102·09	2·514	·588	240·52	4·323	·414
150	164·18	3·022	+0·234	117·48	2·586	·590	255·59	4·450	·467
165	178·20	3·024	0·537	132·79	2·643	·545	270·67	4·534	·485
180	192·68	2·980	0·804	147·92	2·677	·456	285·75	4·569	·463
195	207·81	2·901	1·008	162·84	2·679	·330	300·80	4·542	·404
210	223·56	2·808	1·132	177·59	2·646	·181	315·81	4·464	·315
225	239·75	2·721	1·166	192·22	2·582	+0·025	330·78	4·339	·205
240	256·05	2·652	1·114	206·83	2·492	−0·124	345·72	4·183	+0·088
255	272·06	2·605	0·986	221·53	2·388	·253	0·63	4·011	−0·027
270	287·50	2·572	0·799	236·40	2·281	·356	15·55	3·839	·131
285	302·28	2·544	0·571	251·46	2·181	·427	30·50	3·679	·217
300	316·51	2·512	0·321	266·71	2·096	·467	45·49	3·540	·284
315	330·38	2·470	+0·063	282·09	2·033	·475	60·52	3·428	·329
330	344·18	2·422	−0·187	297·48	1·992	·454	75·59	3·347	·351
345	358·20	2·362	0·419	312·79	1·975	·407	90·67	3·300	·353
0	12·68	2·307	−0·622	327·92	1·979	−0·337	105·75	3·285	−0·333

(*To be continued.*)

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. APRIL 10, 1885. No. 6

EDWIN DUNKIN, F.R.S., President, in the Chair.

Lieut. Sidney Gerald Burrard, R.E., Dehra Dun, India;
Rev. James Hardy Honeyburne, M.A., 97 Mulgrave Street, Liverpool;
James McKerrow, Surveyor-General of New Zealand, Wellington, N.Z.
John A. Westwood Oliver, Braehead House, Lochwinnoch, N.B., and 13 Bruton Street, Berkeley Square, W.; and
Major Harry T. Watson, Langley House, Slough, Bucks,

were balloted for and duly elected Fellows of the Society.

On an Observation of the Projection of Jupiter's First Satellite on its own Shadow, made at Dun Echt, Aberdeen. By Dr. R. Copeland.

(*Communicated by the Earl of Crawford and Balcarres.*)

While sketching *Jupiter* on February 18, 1885, I saw an exceedingly black short line extending east and west, slightly to the north of the planet's equator. In moments of the best definition it seemed lenticular (bi-convex) in shape. On consulting the *Nautical Almanac*, however, it turned out to be really the shadow of Satellite I. on the planet, almost totally occulted by the satellite itself. A sketch was made representing the appearance about $11^h\ 45^m$ G.M.T., as seen with a power of 229 on the 15-inch Equatorial. As the satellite approached *Jupiter's* preceding limb it came out quite bright and large, with a mere crescent of the shadow showing on its southern edge.

The great "red" spot was distinctly visible, although it is now of a pale sandy colour, somewhat whiter along its major axis. It exhibits a certain amount of delicate structure parallel to its margin. The red spot was on the central meridian at $12^h\ 10^m$ G.M.T.

As the opposition of *Jupiter* occurred at 8 A.M. on February 19, it seemed not improbable that the transit of the 2nd satellite on that day, and of the 1st satellite on the 20th, might also be attended by a partial concealment of their shadows. Telegraphic notice was accordingly sent to several correspondents inviting co-operation.

Near the middle of the transit of the 2nd satellite's shadow on the 19th, the shadow seemed almost perfectly round, the satellite being indistinguishable without an exact knowledge of its position. It was not until about half an hour before the egress, when the satellite began to be plainly visible, that it appeared to encroach upon its shadow to an appreciable extent. In this instance, therefore, the diminution of the shadow seems to have been quite as much due to the irradiation of light around the relatively bright satellite, as to an actual occultation of the shadow. A second drawing was made showing the slight deformation of the shadow, and also giving the detail of the belts as they appeared about $14^h\ 15^m$ G.M.T. The observed Greenwich mean times at egress were:

		h	m	s
II.	Tr. E. begins	14	28	8
II.	Tr. E. ends	14	32	53
II.	Sh. E. ends	14	33	53

Dun Echt Observatory:
1885, *April* 6.

Occultation of Aldebaran, 1885, *February* 22, *observed at Dun Echt, Aberdeen.* By Dr. R. Copeland.

(*Communicated by the Earl of Crawford and Balcarres.*

Occultation of Aldebaran, 1885, *February* 22.

	Dun Echt M.T. h m s	Instrument.	Power.	Observer.
Disappearance	4 56 0·1	15-in. Grubb	132	Ralph Copeland
Reappearance	5 [52] 39·9	"	"	"
Disappearance	4 56 0·35	6-in. Simms	94	J. G. Lohse
Reappearance	5 52 41·2	"	"	"

In each case the phenomenon was instantaneous. A strong gale was blowing at the time.

The time of reappearance was recorded, at the 15-inch, one minute later than that given, which agrees with the computed time and with Mr. Lohse's observation.

Dun Echt Observatory:
1885, *April* 6.

Occultations of Stars by the Moon in the years 1876–1880, *and resulting Final Equations between the Errors of the Tables and the Errors of Observation.* By G. L. Tupman.

The place of observation was a few hundred yards east of the Royal Observatory, Greenwich. The chronometer employed (Fletcher 1050) was compared, by the intervention of another, with the sidereal standard clock of the Royal Observatory, a few hours before and after every recorded occultation. The Greenwich mean times have been calculated in the usual way from the sidereal time at mean noon given in the *Nautical Almanac.*

The telescope generally used was an Equatorial of $4\frac{1}{2}$ inches aperture, furnished with position circle and crossed-bar micrometer with power 66. For observing emersions one of the bars was placed to cut off a small segment of the Moon's limb at the expected point of reappearance of the star.

The final equations between the errors of Hansen's Tables and the errors of observation have been calculated by the method employed at the Royal Observatory, described in the Introduction to the *Greenwich Observations* and in Main's *Spherical Astronomy.*

The observed time is supposed to be increased by t^s; the star's Right Ascension and North Polar Distance by e'' and f'' (seconds of arc); the Moon's R.A. and N.P.D. by x'' and y''; and the parallax and semidiameter are supposed to be multiplied by $\left(1+\frac{m}{1000}\right)$ and $\left(1+\frac{n}{1000}\right)$ respectively.

The Moon's Right Ascension and North Polar Distance were interpolated, with second differences, from the hourly ephemeris in the *Nautical Almanac,* which did not, in these years, include Professor Newcomb's correction. The Equatorial horizontal parallax and semidiameter were interpolated, also with second differences, from the same work.

The apparent places of the stars have been taken, generally, from the section "Elements of Occultations" in the *Nautical Almanac.* For the smaller stars the mean places were brought up from the catalogues indicated, and the reductions to apparent place computed by means of the "Independent Constants." The final equations have been computed for such stars because it is probable, from the brightness of the stars, that modern observations of them will, before long, be obtainable.

In the calculation of the geocentric place of the "Corresponding Point" on the Moon's limb, the place of observation (except for the first one) has been assumed to be in

Longitude	0h 0m 2s·62 East of the Royal Observatory.
Astronomical Latitude	51° 28′ 34″·8 N.
Geocentric Latitude...	51 17 21·2

which latitude was obtained by triangulation from the Royal Observatory. Thirteen pairs of stars observed by Talcott's method in 1880 with the Zenith Telescope belonging to the Society gave the mean result:

$$51^\circ\ 28'\ 35''{\cdot}8 \pm 0''{\cdot}4.$$

1876, *April* 7.—Disappearance of BAC 4225 at the Moon's bright limb,* observed from the South Ground of the Royal Observatory with detached telescope; wind troublesome; star faint; near Moon's south limb:

Greenwich Mean Solar Time	8h 27m 52s·0
Star's App. R.A.	12 25 17·78. N.P.D. 94° 22′ 19″·6 (N.A.)
Final Equation	$+1''{\cdot}02 = -{\cdot}1088\,(c''-x'') - {\cdot}2280t$
	$+{\cdot}9940f'' \quad -2{\cdot}5919m$
	$-{\cdot}9940y'' \quad -{\cdot}9305n$

1877, *February* 26.—Disappearance of *α Leonis* at the dark limb:

G.M.T.	12h 45m 44s·67
Star's App. R.A.	10 1 51·51. N.P.D. 77° 26′ 4″·1 (N.A.)
Final Equation	$+11''{\cdot}53 = +{\cdot}8498\,(c''-x'') - {\cdot}4987t$
	$+{\cdot}4884f'' \quad -0{\cdot}5132m$
	$-{\cdot}4876y'' \quad -{\cdot}9988n$

1877, *February* 26.—Reappearance of *α Leonis* at the bright limb:

G.M.T.	13h 51m 8s·46. "Late."
Final Equation	$-10''{\cdot}43 = -{\cdot}7518\,(c-x) + {\cdot}5193t$
	$-{\cdot}6349f \quad +0{\cdot}5099m$
	$+{\cdot}6355y \quad -{\cdot}9987n$

* Because nearly full.

1878, *May* 5.—Disappearance of Yarnall 2332 at the dark limb:

G.M.T.	h m s 8 16 26·09	
Star's App. R.A.	5 31 21·92.	N.P.D. 63° 27′ 9″·1 (Yarnall)
Final Equation	$+17''\cdot34 = +\cdot6193\,(e-x) - \cdot4210t$ $+\cdot7182f \quad -0\cdot1743m$ $-\cdot7170y \quad -\cdot9282n$	

1878, *May* 5.—Disappearance of Yarnall 2355 at the dark limb:

G.M.T.	h m s 9 15 14·92	
Star's App. R.A.	5 34 1·51.	N.P.D. 63° 26′ 51″·9 (Yarnall)
Final Equation	$+19''\cdot00 = +\cdot8033\,(e-x) - \cdot5450t$ $+\cdot4284f \quad +0\cdot8071m$ $-\cdot4266y \quad -\cdot9285n$	

1878, *November* 10.—Disappearance of *η Tauri* at the bright limb:

G.M.T.	h m s 11 11 5·05.	"Very good."
Star's App. R.A.	3 40 19·27.	N.P.D. 66° 16′ 3″·9 (N.A.)
Final Equation	$+4''\cdot26 = +\cdot7593\,(e-x) - \cdot2335t$ $+\cdot5546f \quad -1\cdot3713m$ $-\cdot5532y \quad -\cdot8976n$	

1878, *November* 10.—Reappearance of 20 *Tauri* at the dark limb: 21^h after full moon:

G.M.T.	h m s 11 21 46·05.	"Pretty good."
Star's App. R.A.	3 38 39·37.	N.P.D. 66° 0′ 32″·5 (N.A.)
Final Equation	$-7''\cdot26 = -\cdot8414\,(e-x) + \cdot2856t$ $-\cdot3819f \quad +1\cdot0508m$ $+\cdot3835y \quad -\cdot8977n$	

1879, *March* 2.—Disappearance of 139 *Tauri* at the dark limb:

G.M.T.	h m s 4 52 39·32.	"Full daylight: star held steadily until extinguished."
Star's App. R.A.	5 50 31·40.	N.P.D. 64° 3′ 40″·2 (N.A.)
Final Equation	$+6''\cdot50 = +\cdot8126\,(e-x) - \cdot3605t$ $+\cdot4203f \quad -1\cdot7390m$ $-\cdot4185y \quad -\cdot9149n$	

1879, *March* 2.—Reappearance of 139 *Tauri* at the bright limb:

	h m s	
G.M.T.	6 4 32·21.	"Excellent."
Final Equation	$-5''\cdot16 = -\cdot8172\,(e-x) + \cdot3430t$	
	$+\cdot4105f \quad -0\cdot0665m$	
	$-\cdot4087y \quad -\cdot9155n$	

1879, *March* 3.—Disappearance of ω *Geminorum* at the dark limb:

	h m s	
G.M.T.	9 18 46·84	
Star's App. R.A.	6 55 4·88.	N.P.D. 65° 36′ 46″·4 (N.A.)
Final Equation	$+4''\cdot89 = +\cdot8364\,(e-x) - \cdot3146t$	
	$-\cdot3911f \quad +1\cdot1977m$	
	$+\cdot3929y \quad -\cdot9308n$	

1879, *March* 3.—Reappearance of ω *Geminorum* at the bright limb:

	h m s	
G.M.T.	10 16 16·43.	"Star just clear."
Final Equations	$-5''\cdot81 = -\cdot4865\,(e-x) + \cdot3290t$	
	$-\cdot8442f \quad +0\cdot8112m$	
	$+\cdot8448y \quad -\cdot9314n$	

1879, *March* 30.—Disappearance of BAC 2154 at the dark limb:

	h m s	
G.M.T.	7 16 4·13.	"Near south limb."
Star's App. R.A.	6 30 4·54.	N.P.D. 65° 18′ 36″·9 (N.A.)
Final Equation	$+1''\cdot26 = +\cdot2145\,(e-x) - \cdot1766t$	
	$+\cdot9717f \quad -1\cdot3374m$	
	$-\cdot9715y \quad -\cdot9140n$	

1879, *April* 26.—Disappearance of BB. VI. + 24°, 1263 at the dark limb:

	h m s	
G.M.T.	9 8 51·93	
Star's App. R.A.	6 18 52·75.	N.P.D. 65° 11′ 43″·3 (BB. VI.)
Final Equation	$+9''\cdot58 = +\cdot9030\,(e-x) - \cdot4812t$	
	$+\cdot0251f \quad +1\cdot9605m$	
	$-\cdot0231y \quad -\cdot9044n$	

1879, *May* 3.—Disappearance of *q Virginis* at the dark limb:

	h m s	
G.M.T.	9 19 33·17	
Star's App. R.A.	12 27 34·88.	N.P.D. 98° 47′ 24″·8 (N.A.)
Final Equation	$+9''\cdot26 = +\cdot8997\,(e-x) - \cdot2546t$	
	$-\cdot4178f \quad +1\cdot1153m$	
	$+\cdot4172y \quad -\cdot9953n$	

1879, *July* 28.—Disappearance of *α Scorpii* at the dark limb:

	h m s	
G.M.T.	9 37 39·34.	"Almost instantaneous."
Star's App. R.A.	16 22 3·45.	N.P.D. 116° 9′ 56″·6 (N.A.)
Final Equation	$+5''\cdot58 = +\cdot4055\,(e-x) - \cdot1756t$	
	$-\cdot8941f \quad +3\cdot4441m$	
	$+\cdot8937y \quad -\cdot9726n$	

1879, *July* 28.—Reappearance of *α Scorpii* at the bright limb:

	h m s	
G.M.T.	10 6 45·88.	"Instantaneous; near the north limb."
Final Equation	$-2''\cdot43 = -\cdot3258\,(e-x) + \cdot1840t$	
	$-\cdot9327f \quad +2\cdot6675m$	
	$+\cdot9325y \quad -\cdot9725n$	

1879, *August* 25.—Disappearance of Bradley 2174 at the dark limb:

	h m s	
G.M.T.	8 5 38·71	
Star's App. R.A.	17 6 45·92.	N.P.D. 116° 50′ 26″·3 (N.A.)
Final Equation	$+15''\cdot23 = +\cdot8596\,(e-x) - \cdot4192t$	
	$-\cdot2950f \quad +1\cdot6678m$	
	$+\cdot2930y \quad -\cdot9644n$	

1879, *October* 24.—Disappearance of *θ Aquarii* at the dark limb:

	h m s	
G.M.T.	7 12 38·28.	"Hardly instantaneous."
Star's App. R.A.	22 10 31·00.	N.P.D. 98° 22′ 44″·5 (N.A.)
Final Equation	$+12''\cdot04 = +\cdot6310\,(e-x) - \cdot3773t$	
	$-\cdot7712f \quad +1\cdot9596m$	
	$+\cdot7710y \quad -\cdot9179n$	

1879, *November* 18.—Disappearance of σ *Capricorni* at the dark limb:

	h m s
G.M.T.	6 35 41·39
Star's App. R.A.	20 12 28·21. N.P.D. 109° 29′ 32″·7 (N.A.)
Final Equation	$+11''{\cdot}12 = +{\cdot}9393\,(e-x) - {\cdot}4412t$
	$-{\cdot}1332f \quad +1{\cdot}6171m$
	$+{\cdot}1316y \quad -{\cdot}9593n$

1879, *December* 22.—Disappearance of 101 *Piscium* at the dark limb:

	h m s
G.M.T.	5 6 58·20
Star's App. R.A.	1 29 22·92. N.P.D. 75° 56′ 58″·6 (N.A.)
Final Equation	$+5''{\cdot}59 = +{\cdot}8608\,(e-x) - {\cdot}2178t$
	$+{\cdot}4569f \quad -1{\cdot}9730m$
	$-{\cdot}4561y \quad -{\cdot}8911n$

1880, *January* 19.—Disappearance of BB. VI.+17°, 327 at the dark limb:

	h m s
G.M.T.	8 43 7·58
Star's App. R.A.	2 6 0·01. N.P.D. 72° 32′ 22″·0 (BB. VI.)
Final Equation	$+5''{\cdot}08 = +{\cdot}8865\,(e-x) - {\cdot}2894t$
	$+{\cdot}3616f \quad +0{\cdot}4656m$
	$-{\cdot}3604y \quad -{\cdot}8919n$

1880, *February* 12.—Disappearance of κ *Piscium* at the dark limb:

	h m s
G.M.T.	5 32 28·31
Star's App. R.A.	23 20 47·13. N.P.D. 89° 24′ 2″·4 (N.A.)
Final Equation	$+10''{\cdot}14 = +{\cdot}4352\,(e-x) - {\cdot}3880t$
	$-{\cdot}9003f \quad +3{\cdot}1440m$
	$+{\cdot}9003y \quad -{\cdot}9323n$

1880, *February* 17.—Disappearance of WB_2 III. 538 at the dark limb:

	h m s
G.M.T.	8 39 54·3
Star's App. R.A.	3 27 29·80. N.P.D. 67° 38′ 31″·2 (WB_2)
Final Equation	$+8''{\cdot}93 = +{\cdot}8806\,(e-x) - {\cdot}3522t$
	$+{\cdot}2948f \quad +0{\cdot}8508m$
	$-{\cdot}2932y \quad -{\cdot}8891n$

1880, *February* 17.—Disappearance of WB_2 III. 554 at the dark limb:

	h m s	
G.M.T.	9 18 37·3.	"Near north limb."
Star's App. R.A.	3 27 53·51.	N.P.D. 67° 17′ 58″·1 (WB_2)
Final Equation	$+2''\cdot65 = +\cdot2733\,(e-x) - \cdot1646t$	
	$-\cdot9549f \quad +2\cdot2962m$	
	$+\cdot9551y \quad -\cdot8890n$	

1880, *February* 17.—Disappearance of BB. VI. +22°, 516 at the dark limb:

	h m s	
G.M.T.	9 48 50·3	
Star's App. R.A.	3 29 31·95.	N.P.D. 67° 28′ 15″·6 (BB. VI.)
Final Equation	$+2''\cdot52 = +\cdot9064\,(e-x) - \cdot4200t$	
	$-\cdot1707f \quad +2\cdot1069m$	
	$+\cdot1725y \quad -\cdot8890n$	

1880, *March* 13.—Disappearance of 101 *Piscium* at the dark limb:

	h m s	
G.M.T.	7 34 35·98	
Star's App. R.A.	1 29 22·03.	N.P.D. 75° 57′ 4″·3 (N.A.)
Final Equation	$+6''\cdot89 = +\cdot9612\,(e-x) - \cdot4485t$	
	$+\cdot1092f \quad +1\cdot7744m$	
	$-\cdot1080y \quad -\cdot9047n$	

1880, *March* 15.—Disappearance of DM+21°, 426 at the dark limb:

	h m s	
G.M.T.	6 43 42·39	
Star's App. R.A.	3 6 22·30.*	N.P.D. 68° 49′ 25″·0 (D.M.)
Final Equation	$-15''\cdot08 = +\cdot9270\,(e-x) - \cdot3946t$	
	$-\cdot0657f \quad +1\cdot6381m$	
	$+\cdot0675y \quad -\cdot8919n$	

* The star's R.A. evidently requires a correction of about $-1^s\cdot5$.

1880, *March* 17.—Disappearance of BAC 1518 at the dark limb:

	h m s	
G.M.T.	6 12 21·34	
Star's App. R.A.	4 48 58·75.	N.P.D. 65° 36′ 3″·5 (N.A.)
Final Equation	$+5''\cdot92 = +\cdot8870\,(e-x) - \cdot3477t$	
	$+\cdot2119f \quad +0\cdot2466m$	
	$-\cdot2101y \quad -\cdot8879n$	

1880, *March* 17.—Disappearance of WB_2 IV. 1193 at the dark limb:

	h m s	
G.M.T.	9 21 58·58	
Star's App. R.A.	4 54 18·43.	N.P.D. 65° 31′ 44″·6 (WB_2)
Final Equation	$+12''\cdot80 = +\cdot8616\,(e-x) - \cdot3965t$	
	$-\cdot3100f \quad +2\cdot3103m$	
	$+\cdot3118y \quad -\cdot8880n$	

1880, *March* 17.—Disappearance of DM+24°, 730 at the dark limb:

	h m s	
G.M.T.	9 46 43·89	
Star's App. R.A.	4 55 5·89.	N.P.D. 65° 41′ 14″·4 (D.M.)
Final Equation	$+20''\cdot36 = +\cdot8728\,(e-x) - \cdot4375t$	
	$+\cdot2727f \quad +1\cdot2746m$	
	$-\cdot2709y \quad -\cdot8880n$	

1880, *March* 17.—Disappearance of WB_2 IV. 1227 at the dark limb:

	h m s	
G.M.T.	10 13 7·79	
Star's App. R.A.	4 55 28·45.	N.P.D. 65° 51′ 26″·4 (WB_2)
Final Equation	$+0''\cdot55 = +\cdot4403\,(e-x) - \cdot2594t$	
	$+\cdot8746f \quad -0\cdot8815m$	
	$-\cdot8742y \quad -\cdot8880n$	

1880, *March* 17.—Disappearance of DM+24°, 738 at the dark limb:

	h m s	
G.M.T.	10 15 44·89	
Star's App. R.A.	4 56 2·90.	N.P.D. 65° 41′ 46″·5 (D.M.)
Final Equation	$+36''\cdot64 = +\cdot8829\,(e-x) - \cdot4664t$	
	$+\cdot2304f \quad +1\cdot4320m$	
	$-\cdot2286y \quad -\cdot8880n$	

1880, *March* 17.—Disappearance of 103 *Tauri* at the dark limb:

	h m s	
G.M.T.	12 30 21·91	
Star's App. R.A.	5 0 49·62.	N.P.D. 65° 53′ 36″·3 (N.A.)
Final Equation	$+5''\cdot68 = +\cdot7248\,(e-x) - \cdot4583t$	
	$+\cdot6018f \quad -0\cdot0073m$	
	$-\cdot6006y \quad -\cdot8881n$	

1880, *March* 21.—Disappearance of d^2 *Cancri* at the dark limb:

	h m s
G.M.T.	7 16 25·69
Star's App. R.A.	8 19 4·87. N.P.D. 72° 33′ 42″·3 (N.A.)
Final Equation	$+6''\cdot24 = +\cdot9294\,(e-x) - \cdot3153t$
	$-\cdot2128f \quad -0\cdot1605m$
	$+\cdot2142y \quad -\ \cdot9127n$

1880, *April* 16.—Disappearance of WB_2 VII. 326 at the dark limb:

	h m s
G.M.T.	8 52 23·73
Star's App. R.A.	7 12 7·54. N.P.D. 68° 49′ 5″·7 (WB_2)
Final Equation	$+2''\cdot76 = +\cdot9290\,(e-x) - \cdot3947t$
	$-\cdot0139f \quad +1\cdot6032m$
	$+\cdot0157y \quad -\ \cdot8944n$

1880, *April* 16.—Disappearance of BB. VI.+21°, 1575 at the dark limb:

	h m s
G.M.T.	9 20 3·95
Star's App. R.A.	7 12 54·25. N.P.D. 68° 56′ 27″·2 (BB. VI.)
Final Equation	$+3''\cdot89 = +\cdot9107\,(e-x) - \cdot4331t$
	$+\cdot2009f \quad +1\cdot2864m$
	$-\cdot1992y \quad -\ \cdot8945n$

1880, *April* 16.—Disappearance of 56 *Geminorum* at the dark limb:

	h m s
G.M.T.	10 42 59·47
Star's App. R.A.	7 14 54·10. N.P.D. 69° 19′ 53″·3 (N.A.)
Final Equation	$+4''\cdot72 = +\cdot4055\,(e-x) - \cdot3403t$
	$+\cdot9003f \quad -1\cdot1371m$
	$-\cdot8999y \quad -\ \cdot8949n$

Occultations observed at Forest Lodge, Maresfield. By Captain W. Noble.

1885, *March* 27.—BAC 3529. The sky was slightly hazy, and the Star, which was not particularly well defined, did not go out sharply and suddenly, but rather faded out at the Moon's dark limb at $10^h\ 24^m\ 44^s\cdot5$ local mean time$=10^h\ 24^m\ 26^s\cdot7$ G.M.T. It was at some distance from the bright limb ere it was caught at reappearance.

43 *Leonis.* Subsequently disappeared quite instantaneously at the dark limb at $11^h\ 36^m\ 56^s{\cdot}1$ L.M.T.$=11^h\ 36^m\ 38^s{\cdot}3$ G.M.T. Power 255 adjusted on the first star.

March 28.—BAC 3836. This star disappeared at the dark limb of the Moon in much the same odd way that BAC 3529 did last night; not going out instantaneously, but rather fading out at $10^h\ 19^m\ 42^s{\cdot}6$ L.M.T.$=10^h\ 19^m\ 22^s{\cdot}8$ G.M.T. Power 154 adjusted on the star.

I only put these observations on record on account of the odd behaviour of the two stars BAC 3529 and BAC 3836. The effect in the latter case was precisely that which would have been presented had the star had a measurable objective disc (instead of its mere diffraction one) and a conical mountain on the Lunar limb had passed obliquely over it.

Forest Lodge, Maresfield, Uckfield:
1885, *April* 9.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XLV. May 8, 1885. No. 7

Edwin Dunkin, F.R.S., President, in the Chair.

Professor C. H. Brewitt Taylor, Foo-Chou Arsenal, China, was balloted for and duly elected a Fellow of the Society.

The Astronomer Royal desires to give notice that having several spare copies of Col. Tennant's "Report on the Transit of *Venus*, 1874" in stock at the Royal Observatory, he will be willing to present copies to any Fellows of the Society who may wish for them, on their making application to him for the same.

On the Right Ascensions of the Cape Catalogues, 1850, 1860, *and* 1880. By E. J. Stone, M.A., F.R.S.

The comparisons which Mr. Downing has made between the Right Ascensions of the Cape Catalogue, 1880, and those of the Melbourne Catalogue for 1870 (*Monthly Notices*, March 1885, page 301), is some real test of the freedom of the Catalogues compared from systematic errors. The epochs of the two Catalogues are only separated by ten years, and, in most cases, material exists for an approximate determination of the proper motions of the stars. It will be seen that the result justifies the statement which I made in *Notices*, January 1885, that the Right Ascensions made with the Transit Circles of the Melbourne and the Cape were either free from systematic errors, or affected with sensibly equal errors depending upon N.P.D.

But the comparisons which Mr. Downing has made between the Right Ascensions of the Cape Catalogues, 1850, 1860, and 1880, cannot be regarded as reliable tests of the existence of systematic errors in these Catalogues.

This is not due to any want of care or skill on Mr. Down-

ing's part, but to the absence of reliable data. It is impossible to determine the proper motions of the Southern stars contained in these Catalogues with sufficient accuracy to allow the Right Ascensions of the stars to be brought up over periods of twenty or thirty years with a precision which will justify the assumption that differences thus found are due to instrumental defects. For my own part I seriously doubt the legitimacy of such assumptions for the much more frequently observed stars within the reach of our principal northern observatories; and the conclusion to which Mr. Downing has been led (*Notices*, March 1885, page 315), that the proper motions of the clock-stars are not yet sufficiently well determined to allow of their Right Ascensions being brought up for a period of twenty years, is, I venture to think, a sufficient justification of my doubts.

But if these comparisons between the Cape Catalogues, 1850, 1860, 1880, were reliable, then the differences which Mr. Downing has given between the Right Ascensions of the 1880 Catalogue and those for 1850 and 1860 could not be due to errors in the 1880 Catalogue dependent upon N.P.D.

For these comparisons indicate that the Right Ascensions of the Southern stars in the 1880 Catalogue are too *small* relatively to those of the stars near the Equator by about a tenth of a second of time, when compared with the Right Ascensions of the 1850 Catalogue, whilst they are *too large* by about a tenth of a second of time, when compared with the Right Ascensions in the 1860 Catalogue, in the indirect manner adopted by Mr. Downing. Now the Right Ascensions of the Cape Catalogue, 1880, may be either too small or too large, but they certainly cannot be both too small and too large.

I have no hesitation in expressing an opinion that these differences are chiefly due to imperfections in the carrying out of the comparisons.

But as the results of the Cape Catalogue, 1860, are, in my opinion, of great accuracy, and tables of differences, such as those given by Mr. Downing, may lead to false impressions of the accuracy of the results contained in the two Catalogues compared, I have thought it desirable to test the reality of the somewhat large residual difference found for the zone N.P.D. 139° to N.P.D. 156°.

I have found seventy-five stars in the Cape Catalogue for 1860 which have proper motions adopted for them in Right Ascension, in the Melbourne Catalogue, 1870; I have brought up the Right Ascensions of these stars from 1860 to 1880 with these adopted proper motions. The difference which I thus find is only $+0^{s}\cdot05$. But even this small quantity would be diminished if, in the determination of the Melbourne proper motions, Powalky's re-reduction of Lacaille's observations had been used instead of the uncorrected results. I have not, however, thought it worth while to pursue the point further. Powalky has made his re-reduction differential with respect to Bradley's observations as reduced by Bessel; and as Auwers has

shown that these results require some not inconsiderable alterations, it would appear that some further modifications of Powalky's corrections must also be required. I have, however, given one other test of the accuracy of the Right Ascensions of the 1860 Catalogue. I find in the same zone eighty-four stars which are also contained in the 1840 Catalogue. I have, therefore, brought up the Right Ascensions of the 1860 Catalogue to 1880, with the proper motions found for the 1840 and 1880 Catalogues. The mean difference thus found is only $+0^s{\cdot}03$.

Such quantities as these are certainly not larger than those which will be found to result from similar comparisons between the best existing catalogues if separated by intervals of twenty years.

On the Diameters of the Sun and Moon as observed with the Greenwich Transit Circle. By W. G. Thackeray.

(*Communicated by A. M. W. Downing.*)

In one of the numerous sections of "Greenwich Observations" are yearly given the results of the comparisons of the diameters of the Sun and Moon, as computed by the *Nautical Almanac* Office, and as observed with the Greenwich Transit Circle, in the form of error of the *Nautical Almanac* diameter, and the mean of all these errors for the year, with the number of observations on which the value depends, is given in the several introductions.

A discussion of these errors, for several years previous to 1864, led to the adoption of a correction of $-0''{\cdot}53$ to the computed value of the *Nautical Almanac* semi-diameter of the Sun in all cases whenever a single limb only was observed, and this correction, which has continued to accord with the mean annual error year by year, has been still applied up to the present time whenever necessary. While casually looking into the observations on which this correction has been founded, I was drawn into an inquiry as to what is the mean value of the diameter of the Sun and Moon, given by all the observations made with the Greenwich Transit Circle, and what is the special value given by each of the regular observers? In other words, what is the amount of personality hidden away under this uniform annual mean?

The following Tables I. and II. are formed by extracting directly from the several volumes of "Greenwich Observations" the mean annual errors of the *Nautical Almanac* horizontal and vertical diameters of the Sun and Moon, with the number of observations on which they depend, so that the resulting value of the diameter is one which depends on a long series of observations made by various observers, and spread over a number of years.

Tables III. and IV. are formed by taking from one of the planetary sections the daily errors of the *Nautical Almanac*

vertical diameters of the Sun and Moon, as given by each of the regular observers for a period of years, and ranging them under each observer's name, and the tabular figures represent the mean annual error with the number of observations on which the value depends subscribed.

The number of observations of the double limbs of the horizontal diameter of the Moon with the Transit Circle are, unfortunately, not sufficiently numerous to afford any reliable information; but, in the case of the horizontal diameter of the Sun, Mr. Dunkin has already printed in the *Monthly Notices* several papers which exhibit the amount of personality to be expected.

TABLE I.

Apparent Errors of the Duration of Passage of the Sun's Horizontal Diameter, and of the Sun's Vertical Diameter as computed in the "Nautical Almanac."

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.−Obs.	No. of Obs. of Vertical Diameter.	Mean Value of N.A.−Obs.
		s		″
1861	108	+0·10	113	+0·97
1862	81	+0·13	87	+1·11
1863	103	+0·12	107	+1·29
1864	105	+0·08	111	+1·09
1865	104	+0·07	117	+1·02
1866	95	+0·08	103	+1·11
1867	73	+0·11	83	+1·39
1868	111	+0·08	126	+1·33
1869	79	+0·12	93	+1·60
1870	106	+0·12	119	+1·29
1871	103	+0·11	104	+0·65
1872	107	+0·12	109	+0·64
1873	102	+0·11	108	+0·49
1874	94	+0·10	95	+0·17
1875	96	+0·11	104	+0·59
1876	99	+0·11	96	+1·03
1877	75	+0·10	75	+1·02
1878	77	+0·10	72	+1·34
1879	61	+0·09	64	+1·33
1880	99	+0·08	104	+1·38
1881	107	+0·09	108	+0·93
1882	87	+0·08	97	+0·68
1883	113	+0·05	122	+0·87

Weighting these results according to the number of observations in each year, and remarking that in the case of the duration of the passage of the horizontal diameter we shall not be much in

error in multiplying by 14 to convert into seconds of arc, we obtain

Period.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.—Obs.	No. of Obs. of Vertical Diameter.	Mean Value of N.A.—Obs.
		s		″
1861–83	2185	+0·097	2317	+1·00
		or +1″·36		

Remarking that the assumed value of the *Nautical Almanac* diameter of the Sun at the Earth's mean distance has been 32′ 3″·64 since 1853, and changing the sign of the errors to obtain the corrections, we get

Period.	No. of Obs.	Corrected Hor. Diam.	No. of Obs.	Corrected Vert. Diam.
1861–83	2185	32′ 2″·28	2317	32′ 2″·62

In vol. 22 of the *Monthly Notices*, in a paper entitled 'On the Circularity of the Sun,' Sir G. B. Airy obtained the following results from the diameter:—

Period.	No. of Obs. Hor. Diam.	Corrected Hor. Diam.	No. of Obs. Vert. Diam.	Corrected Vert. Diam.
1853–60	795	32′ 2″·65	851	32′ 2″·61

Combining the two results together, and weighting them according to the number of observations, we finally obtain

1853–80	2980	32′ 2″·38	3168	32′ 2″·62

It seems curious that the values of the vertical diameter for the two periods 1853-60 and 1861-83 should be nearly identical, while those of the horizontal diameter should differ by 0″·37; but this difference may with great probability be ascribed to a change in the observing staff, and the consequent change in the mean value of the personality of all the observers. As it may be instructive to trace the changes made in the staff of the Observatory, we therefore record, as shortly as possible, the history bearing on this point.

In 1853, the Rev. R. Main was chief assistant, and the other assistants were Messrs. Henry, Dunkin, Breen, Ellis, and Todd. Mr. Breen superintended the computers and virtually did no observing.

In 1854, Mr. Todd resigned, and was succeeded by Mr. Criswick.

In 1857, Mr. Henry died, and was replaced by Mr. Lynn.

In 1859, Mr. Breen resigned, and Mr. Lynn superintended computers and virtually did no observing, and Mr. James Carpenter was appointed an assistant.

In 1860, Mr. Main resigned, and Mr. Stone was appointed in his place, and no change took place in the staff till,

In 1870, Mr. Stone resigned, and Mr. Christie took his place. Mr. Dunkin was made superintendent of computers and did no observing, and Mr. Lynn became an observing assistant.

In 1873, Mr. Downing was appointed in the place of Mr. James Carpenter, who resigned, and Mr. Maunder was appointed physical assistant.

In 1875, Mr. Thackeray succeeded Mr. Glaisher, who resigned, and Mr. Ellis was transferred to superintend the Magnetical and Meteorological Observatory.

From 1877 till 1880, Mr. Lynn was ill and did little or no observing, so that a great many more computers than usual were employed in making observations.

In 1881, Mr. Lewis succeeded Mr. Lynn, who resigned in 1880.

In 1882, the vacancy caused by the appointments of Mr. Christie and Mr. Dunkin to be respectively Astronomer Royal and Chief Assistant, was filled up by Mr. Hollis, and Mr. Criswick was made superintendent of computers, and ceased to be an observing assistant. Since that time the staff has remained the same.

We may fairly assume therefore that the mean value of the two diameters, viz., 32′ 2″·5, would very accurately represent the diameter of the Sun as seen in the Greenwich Transit Circle by a being whom we will designate for want of a better name, a "mean observer."

TABLE II.

Apparent Errors of the Duration of Passage of the Moon's Horizontal and Vertical Diameter as computed in the "Nautical Almanac."

Year.	No. of Obs. Hor. Diam.	Mean Value of N.A.−Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.−Obs.	Mean N.A. Diameter.	
		s		″	′	″
1856	3	−0·05	13	−2·02	31	9·22
1857	3	+0·13	11	+1·03	31	9·36
1858	5	+0·07	15	+0·92	...	...
1859	4	+0·14	16	+2·39	...	...
1860	1	+0·05	9	+2·11	...	...
1861	2	+0·11	10	+0·93	...	...
1862	2	+0·08	1	+0·25	31	8·20
1863	3	+0·02	7	−1·43	...	...
1864	2	+0·06	5	−0·49	...	...
1865	4	+0·08	7	+0·03	..	...
1866	2	+0·09	7	+0·81	...	...
1867	3	+0·17	2	−0·09	...	...
1868	4	−0·03	13	+0·90	...	...
1869	2	−0·03	4	+1·31	...	...
1870			5	−0·36	...	...
1871	2	+0·04	7	+0·72	...	...
1872	2	−0·03	5	−1·34	...	...
1873	2	+0·08	8	+0·27	...	...
1874	2	−0·03	12	−1·41	...	...

Year.	No. of Obs. Hor. Diam.	Mean Value of N.A.–Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.–Obs.	Mean N.A. Diameter.
		s		"	′ "
1875	2	+0·17	8	+0·49	... ...
1876	4	+0·17	3	–3·62	... ...
1877	2	+0·05	9	–0·99	... ...
1878	1	–0·20	6	+0·83	... ...
1879	1	+0·12	8	–0·16	... ...
1880	2	+0·01	14	–0·29	... ...
1881	2	+0·06	14	–0·45	... ...
1882	4	–0·03	21	–0·19	... ...
1883			11	–0·84	... ...

Grouping these figures according to the different values of diameter, we obtain

Period.	No. of Obs. Hor. Diam.	Mean Value of N.A.–Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.–Obs.	Mean N.A. Diameter.
				"	′ "
1856	3	–0s·050 or –0″·70	13	–2·02	31 9·22
1857–61	15	+0s·105 or +1″·47	61	+1·38	31 9·36
1862–83	48	+0s·049 or +0″·69	187	–0·25	31 8·20

Since 1862, Hansen's Tables have been used in the *Nautical Almanac*, and taking the value of the Moon's semi-diameter as given by Hansen =num. (log = 4·750519) × sin(parallax equatorial and horizontal), and assuming the value of the mean equatorial horizontal parallax to be that given by Adams, viz., 57′ 2″·3, we find the corresponding value of the diameter to be 31′ 8″·20. Therefore, using this value, we obtain

Period.	No. of Obs. Hor. Diam.	Corrected Hor. Diam.	No. of Obs. Vert. Diam.	Corrected Vert. Diam.
		′ "		′ "
1856	3	31 9·92	13	31 11·24
1857–61	15	31 7·89	61	31 7·98
1862–83	48	31 7·51	187	31 8·45

Combining these results together, we finally obtain

1856–83	66	31′ 7″·71	261	31′ 8″·48

Considering the number of observations and the difficulties under which these observations are frequently made, one of the limbs being generally more or less rugged and defective in illumination, the agreement is as near as can be expected, and tends to prove that the value of the diameter as used in the *Nautical Almanac* is very satisfactory.

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	$''$	$''$	$''$	$''$	$''$	$''$	$''$	$''$	$''$
1875				$+2.55_{15}$	-1.14_{10}	$+1.13_{14}$	$+1.41_{12}$		
1876				$+2.33_{14}$	-1.23_{9}	$+1.79_{19}$	$+0.45_{18}$		
1877				$+2.86_{10}$		$+2.46_{11}$	-0.59_{12}		
1878				$+1.86_{10}$		$+2.72_{16}$	-0.08_{9}		
1879				$+2.06_{11}$		$+2.11_{14}$	$+2.09_{9}$		
1880				$+1.50_{15}$		$+2.26_{25}$	$+1.37_{19}$		
1881				$+1.96_{15}$		$+2.31_{22}$	$+1.42_{17}$	-0.26_{23}	
1882						$+1.47_{14}$	$+0.89_{21}$	$+0.81_{18}$	-0.18_{25}
1883						$+2.45_{21}$	$+1.51_{24}$	$+1.01_{21}$	$+0.59_{19}$
Means	$+2.28_{138}$	-0.19_{260}	$+3.13_{191}$	$+1.65_{147}$	-1.59_{149}	$+1.70_{202}$	$+1.01_{141}$	$+0.48_{62}$	$+0.15_{44}$
Probable error of Means	± 0.068	± 0.065	± 0.063	± 0.041	± 0.087	± 0.055	± 0.068	± 0.1143	± 0.1441
Probable error of a single obs.	± 0.799	± 1.066	± 0.871	± 0.764	± 1.062	± 0.784	± 0.807	± 0.900	± 0.934

Mean of all observers ... ... $+1''.11_{1544} \pm 0.0221$

TABLE III.

Mean Annual Value of the Error of the Vertical Diameter of the Sun as computed in the "Nautical Almanac."

Year.		Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
		$''$	$''$	$''$	$''$	$''$	$''$	$'$	$''$	$''$
1861	... ...	$+2.33_{14}$	-0.14_{18}	$+1.93_{9}$	$+0.92_{19}$					
1862	... ...	$+1.62_{7}$	-0.18_{13}	$+2.55_{14}$	$+1.19_{18}$					
1863	... ...	$+2.23_{16}$	$+0.24_{28}$	$+3.21_{21}$	$+1.02_{19}$					
1864	... ...	$+2.37_{17}$	-0.67_{21}	$+3.31_{19}$	$+1.19_{27}$					
1865	... ...	$+2.32_{18}$	-0.63_{26}	$+2.71_{19}$	$+1.68_{20}$					
1866	... ...	$+2.34_{18}$	-0.22_{18}	$+2.48_{19}$	$+1.31_{16}$					
1867	... ...	$+2.16_{15}$	-0.17_{19}	$+2.57_{14}$	$+2.35_{14}$					
1868	... ...	$+2.28_{19}$	-0.49_{20}	$+2.78_{14}$	$+1.59_{22}$					
1869	... ...	$+2.50_{14}$	-0.21_{18}	$+4.68_{13}$	$+1.73_{17}$					
1870	... ...		-0.83_{19}	$+3.97_{22}$	$+1.46_{20}$	-0.96_{19}				
1871	... ...		$+0.17_{15}$	$+3.99_{13}$	$+1.74_{17}$	-1.99_{28}				
1872	... ...		$+0.49_{22}$	$+2.96_{14}$	$+1.93_{17}$	-1.75_{23}				
1873	... ...		$+0.61_{18}$		$+1.13_{18}$	-1.26_{20}	$+0.22_{27}$			
1874	... ...		-0.16_{13}		$+1.99_{18}$	-1.79_{20}	$+0.46_{4}$			

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	″	″	″	″	″	″	″	″	″
1875				$+2.55_{15}$	-1.14_{10}	$+1.13_{14}$	$+1.41_{12}$		
1876				$+2.33_{14}$	-1.23_{9}	$+1.79_{19}$	$+0.45_{18}$		
1877				$+2.86_{10}$		$+2.46_{11}$	-0.59_{12}		
1878				$+1.86_{10}$		$+2.72_{16}$	-0.08_{9}		
1879				$+2.06_{11}$		$+2.11_{14}$	$+2.09_{9}$		
1880				$+1.50_{18}$		$+2.26_{25}$	$+1.37_{19}$		
1881				$+1.96_{15}$		$+2.31_{22}$	$+1.42_{17}$	-0.26_{23}	
1882						$+1.47_{14}$	$+0.89_{21}$	$+0.81_{18}$	-0.18_{25}
1883						$+2.45_{21}$	$+1.51_{24}$	$+1.01_{21}$	$+0.59_{19}$
Means	$+2.28_{128}$	-0.19_{269}	$+3.13_{191}$	$+1.65_{347}$	-1.59_{149}	$+1.70_{208}$	$+1.01_{141}$	$+0.48_{62}$	$+0.15_{44}$
Probable error of Means	±0.068	±0.065	±0.063	±0.041	±0.087	±0.055	±0.068	±0.1143	±0.1441
Probable error of a single obs.	±0.799	±1.066	±0.871	±0.764	±1.062	±0.784	±0.807	±0.900	±0.934

Mean of all observers ... ... $+1''.11_{1544} \pm 0.0221$

From these figures it seems clear that the value of the diameter, as depending on the several observers, varies very considerably, the difference in the case of Mr. Lynn and Mr. Carpenter amounting to nearly 5″. The − sign denotes that the micrometer wire is placed by the observer outside, and the + sign, that it is placed within the limbs, as represented by the *Nautical Almanac* diameter. The error, as given by the same observer, varies somewhat from year to year, so that the system adopted at the Washington Observatory in cases of the observation of a single limb, of correcting the diameter from the mean error of all the observations made during the year by the same observer, is preferable to a uniform correction from the mean of all the observers, for in some cases such a correction only aggravates the error it was meant to remedy.

In vol. xxxv., p. 91, of the *Monthly Notices*, Mr. Dunkin has represented the tabular error of the duration of the horizontal diameter of the Sun for the ten years 1864-73 to be as follows:—

Period.	Dunkin.	Ellis.	Criswick.	Lynn.	J. Carpenter.
	s +0·062	s +0·106	s +0·022	s +0·075	s +0·175
1864–73	or	or	or	or	or
	″ +0·87	″ +1·48	″ +0·31	″ +1·05	″ +2·45

Comparing these values with those obtained for the vertical diameter, there appears to be a smaller amount of personality, the greatest difference amounting to a little more than 2″. Mr. Carpenter develops the same strong individuality, and Mr. Lynn reverses the sign of his error, so that his vertical and horizontal diameters differ in value by as much as 2″·64. Assuming that the number of observations made by each of these observers for this period is much the same, the mean error from all the observers would be +1″·23, and taking the mean of the same five observers for observations of the vertical diameter, the mean error is +1″·13, a result which is practically identical with the first.

TABLE IV.

Apparent Errors of the Vertical Diameter of the Moon as computed by the "Nautical Almanac.

Year.			Dunkin.	Ellis.	Criswick.	J. Carpenter.	Lynn.	Downing.	Thackeray.	Lew
			″	″	″	″	″	″	″	
1862	...	...		$+0{\cdot}25_1$						
1863	...	...	$-0{\cdot}95_2$		$+1{\cdot}03_2$	$+0{\cdot}48_1$	$-3{\cdot}25_1$			
1864	...	...		$-1{\cdot}61_1$	$+3{\cdot}06_1$	$+0{\cdot}48_1$				
1865	...	...	$-0{\cdot}72_2$		$+1{\cdot}27_3$	$+1{\cdot}32_1$				
1866	...	...	$+0{\cdot}88_1$	$-0{\cdot}49_3$	$+1{\cdot}11_1$	$+2{\cdot}56_2$				
1867	...	...		$-1{\cdot}11_1$	$+0{\cdot}93_1$					
1868	...	...	$+0{\cdot}32_2$	$-1{\cdot}46_1$	$+1{\cdot}23_4$	$+1{\cdot}51_5$				
1869	...	...			$+1{\cdot}28_4$					
1870	...	...			$-2{\cdot}37_1$	$+1{\cdot}60_1$	$-3{\cdot}64_2$			
1871	...	...		$+0{\cdot}39_2$	$+1{\cdot}36_2$					
1872	...	...		$-1{\cdot}24_1$	$+0{\cdot}09_2$		$-3{\cdot}32_2$			
1873	...	...		$+1{\cdot}62_1$	$-2{\cdot}01_2$		$-6{\cdot}10_1$	$+2{\cdot}02$		

Year.	Dunkin.	Ellis.	Criswick.	J Carpenter.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	"	"	"		"	"	"	"	"
1874		-0.17_6	-1.49_2			-2.28_3			
1875			-1.80_1		-4.48_1	-0.08_3	$+2.24_1$		
1876							-3.90_2		
1877			-0.33_1		-1.13_2	-0.31_1	-2.54_2		
1878			$+3.08_2$			-3.27_1	$+1.61_1$		
1879			-0.23_6				$+0.74_1$		
1880			-0.18_4			$+0.05_5$	-0.83_3		
1881			$+0.79_4$			-1.69_3	-0.05_3	-1.92_2	
1882						-0.98_6	$+0.89_5$	-1.68_3	-0.83_3
1883						$+0.41_2$	$+0.36_2$	-2.69_3	$+0.09_2$
Means	-0.27_7	-0.31_{17}	$+0.46_{42}$	$+1.59_{11}$	-3.34_9	-0.72_{24}	-0.29_{20}	-2.12_8	-0.47_5
Probable error of Means	±0.3817	±0.2768	±0.1526	±0.2206	±0.3968	±0.2454	±0.2535	±0.3167	±0.5998
Probable error of a single obs.	±1.010	±1.141	±0.977	±0.732	±1.191	±1.202	±1.131	±0.895	±1.341

Mean of all the observers ... ... $-0''.31_{143} \pm 0''.0872$.

In forming these tables, three observations in which the errors exceed 6″ were rejected, one by Mr. Dunkin in 1863 (– 7″·39), and two by Mr. Downing in 1873 and 1874 respectively (+7″·27) and (–6″·15).

The resulting errors again point to large personalities in the measurement of the diameter of the Moon as in the case of the Sun, and Mr. Lynn and Mr. Carpenter again differ in their values by nearly 5″·.

Though these results are not entitled to the same value as those of the Sun, on account of the much fewer number of observations, yet taken in connection with those of the Sun, they indicate a very definite and systematic error, as peculiar to an observer as a rate is to a chronometer, and one from which there seems to be no method of escape.

While this personality does not affect the tabular place of the Sun, as the process of taking the mean of the limbs eradicates the mischief, in the course of a lunation the quantities involved seem to be of sufficient magnitude to seriously affect the value of the tabular errors derived from the observations of the Moon.

A Note of an Observation during the Transit of Jupiter's Satellite IV., April 18. By Edmund J. Spitta.

The greater portion of this transit was observed here, both with the 10-inch reflector and three-inch Tulley refractor. Definition fair; temperature 54 F.; barometer 30·14.

The satellite for the greater part of the transit appeared black, as it commonly does; but what I should like to call attention to is, that this blackness remained until egress, *instead of disappearing about ten minutes before*—an observation I believe unique, and seen also by Mr. Gledhill of Bermerside, as well as others.

Further than this nothing unusual occurred, excepting that for about half an hour, between 11 and 11.30, the satellite became exceedingly faint, appearing to me, at times of good definition, irregularly elongated parallel to the belts, assuming then more of a chocolate colour. (Mr. Gledhill also noticed the faintness and ill-defined appearance at the same hour.) I was also struck by the faint appearance both before and after transit of this satellite as compared with the others; and, to use an expression once employed by Dawes, "it was far from obvious."

I may add that Satellite III., during a dark transit on May 2 (temperature 46° F., barometer 29·58, definition good until the time of egress, when it became unsteady) was quite different. While dark, it appeared uniformly round, and of a deep steel colour, and about ten minutes before egress became invisible, but eventually reappeared on the limb of the planet, perfectly white and defined, during good moments of definition.

Ivy House, Clapham Common:
1885, *May* 4.

Total Solar Eclipses Visible in the British Isles 878—1724.
By J. Maguire.

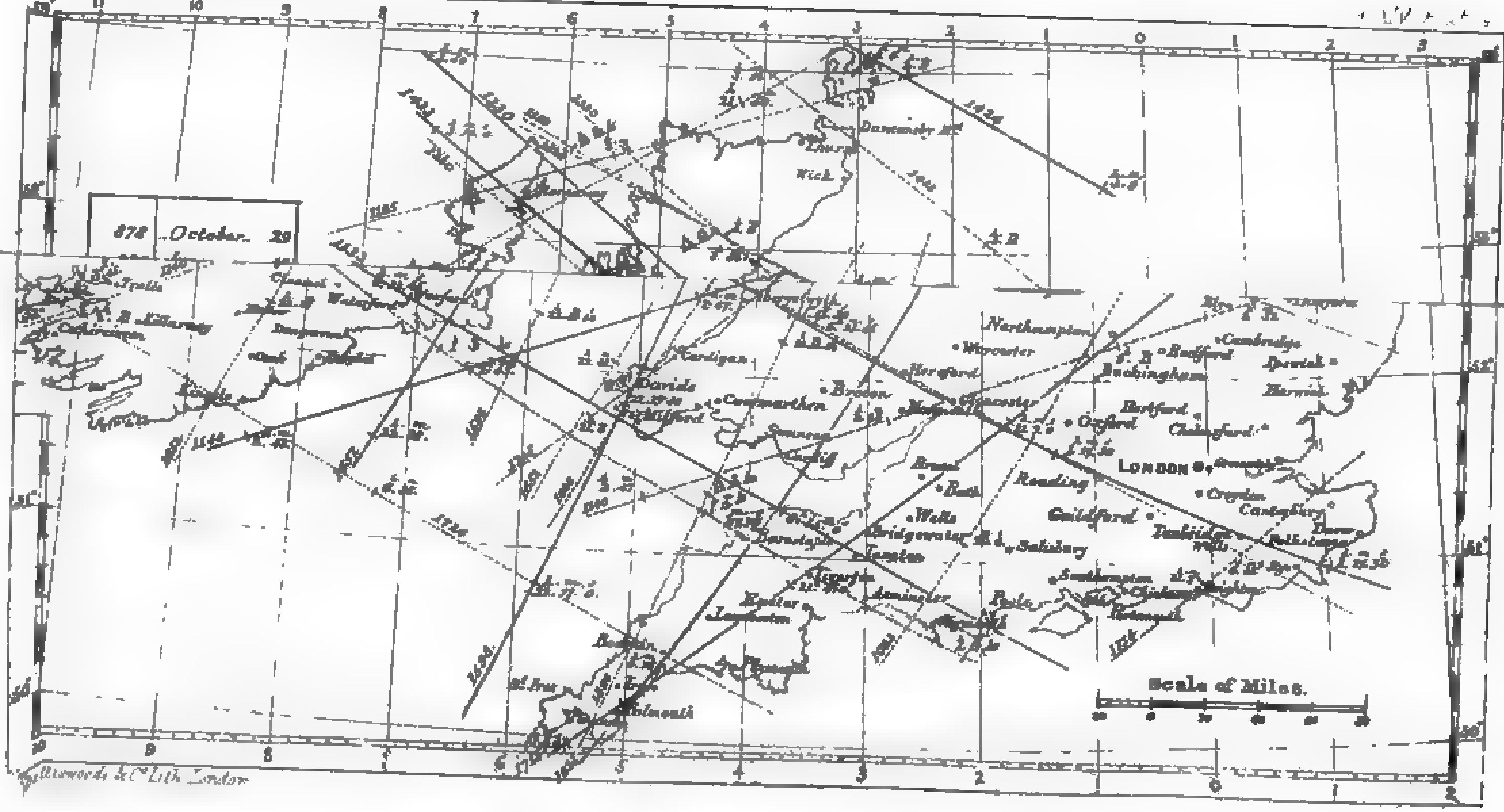
About ten years ago I calculated several if not all the total solar eclipses the central lines of which have touched the British Isles, beginning with the year 878 and ending with 1724. I used Hansen's Tables of the Sun and Moon, and in some cases Leverrier's of the Sun. A small map of the British Isles, showing the central and limiting lines of thirteen eclipses accompanies this paper.

The points for which calculations have been made are marked upon the lines, together with the Greenwich mean time. The width of shadow and the duration on the central lines are given on the list which follows.

It appears from the limiting lines of these eclipses that London has been twice totally eclipsed, Dublin twice, and Edinburgh five times. And assuming the calculations to be correct, the Moon's shadow would have fallen upon every spot of the British Isles except a small space at Dingle, on the West Coast of Ireland.

Date.		G.M.T.	Width of Shadow in miles.	Duration.
		h m s		m s
878	Oct. 29	1 17 30	168	2 13
885	June 15	21 46 0	196	4 55
1023	Jan. 24	0 20 0	130	2 24
1133	Aug. 1	23 23 0	154	4 34
1140	Mar. 20	2 49 0	132	3 26
1185	May 1	2 3 0	154	4 33
1330	July 16	3 54 0	42	0 56
1424	June 26	3 6 0	168	4 14
1433	„ 17	3 15 0	194	4 27
1598	Mar. 6	22 25 30	84	1 34
1652	Apr. 7	22 34 0	122	3 0
1715	May 2	21 7 0	184	4 0
1724	„ 22	6 35 0	136	2 48

Norwich: 1885, *April.*

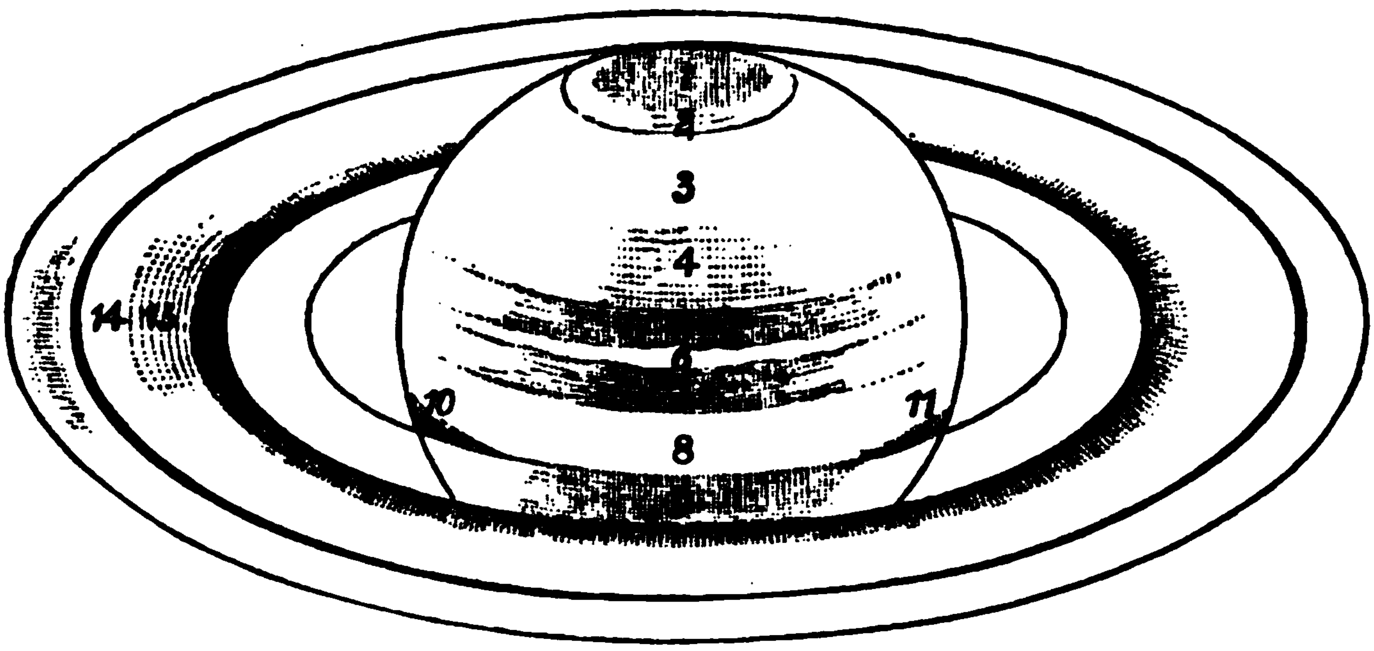

October 29
Northampton
Worcester
Hereford
Gloucester
Bedford
Cambridge
Buckingham
Ipswich
Harwich
Hertford
Chelmsford
Oxford
LONDON
Reading
Croydon
Guildford
Canterbury
Salisbury
Southampton
Poole
Bristol
Bath
Wells
Bridgewater
Taunton
Exeter
Launceston
Brecon
Carmarthen
Cardigan
Swansea
Cardiff
Wick
Waterford
Killarney
Cork
Falmouth
Scale of Miles.

Observations of Saturn. By N. E. Green.

The position of *Saturn* during the opposition now past having been most favourable for viewing the ring system, it will not be out of place to put on record the details of the planet as seen by the aid of an 18-inch reflector.

The mirror employed was figured by Mr. G. With, of Hereford, and is of the finest defining quality; the powers used varied from 250 to 400.

Many studies of the planet were made between Nov. 1884 and Feb. 1885, giving the following results:—



No. 1. South Polar cap, dark gray.
2. Very faint extension of the gray of pole, slightly yellower.
3. Broad band of yellowish-gray light.
4. Broad belt of slightly deeper colour.
5. A well marked narrow dark-gray belt.
6. Very narrow belt of yellowish light, irregular in outline.
7. The darkest belt on the ball, colour warm gray.
8. Equatorial light, very bright in the centre.
9. The edge of the dusky ring, the shade of which is increased by a dark belt on the northern side of the equatorial light. Portions of this belt are seen at 10 and 11; the resulting colour being a blue-gray darker than belt 7.

Details of Rings.

The Dusky Ring.—This extends nearly half-way from the inner edge of the inner ring to the body of the planet, and is bounded by a definite line on the edge nearest the ball.

The Inner Ring.—The inner ring is divided into three zones. The most narrow of these, No. 12, fades gradually into the dusky ring, and is warm in colour. The middle zone is the broadest, and shines with a subdued yellow light; it is bounded

distinctly by the bright zone No. 14, the most brilliant portion of the system.

Cassini's Division.—This division has varied in distinctness, being sometimes better seen either on the eastern or the western ansa.

The Outer Ring.—This ring is the great difficulty of the planet, requiring an opportunity of the most choice kind to determine its markings. The lightest portion is certainly on the side next Cassini's division, but does not come close to it, and on the exterior next the sky there is also a faint line of light. This causes an appearance of shade through the central portion of the ring, but no indication of Encke's division could be detected.

39 *Circus Road,*
St. John's Wood.

Mr. Green has presented to the Society a drawing of *Saturn*, as observed by him in 1884.

Observations of Comet 1884 *III.* (*Wolf*) *at Harrow.* By G. L. Tupman.

The observations were taken with crossed-bar reticule on the $4\frac{1}{2}$-inch equatorial, and power 66. The zero reading of the position circle was carefully determined on eleven nights by a star near the Meridian. The comet had always a well-defined, almost stellar nucleus, which could be very accurately observed. The disappearances and reappearances at the edges of the bars at each transit have been considered as forming a single comparison. The comparisons on Oct. 22, 26, Nov. 18 to end were registered on the chronograph; the others were made by eye and ear. The differences of R.A. and of Declination have been corrected for defective orientation and error of perpendicularity of the bars, for the comet's geocentric motion, and for refraction.

For the parallaxes, log. Δ has been taken from the Ephemeris by Dr. Krueger in the *Astronomische Nachrichten*, with mean solar parallax $8''\cdot83$.

1884.	Green. Mean Time.	☄ − ✱ Δα	☄ − ✱ Δδ	No. of Comp.	☄ app. α	Par.	☄ app. δ	Par.	✱
	h m s	m s	′ ″		h m	s	° ′ ″	″	
Sept. 24	10 38 0	−1 12·81	+6 34·4	11, 11	21 17 23·00	+0·20	+20 36 14·9	+5·8	1 (*a*)
25	9 46 4	−0 22·65	−8 48·8	13, 13	21 17 58·71	+0·10	+20 9 36·8	+5·8	2
27	10 45 50	+2 35·90	−6 30·6	12, 12	21 19 22·53	+0·23	+19 12 31·2	+6·2	3
Oct. 4	9 17 52	+0 19·29	+0 57·6	5, 5	21 25 33·94	−0·12	+15 51 45·5	+6·5	4 (*b*)
	9 59 47	+0 21·28	+0 6·7	6, 6	21 25 35·93	−0·03	+15 50 54·6	+6·5	4
	10 23 34	+0 22·22	−0 18·8	5, 5	21 25 36·87	+0·02	+15 50 29·1	+6·5	4
13	11 29 16	−3 24·43	+2 57·1	9, 9	21 36 55·43	+0·27	+11 23 55·6	+7·3	5
22	9 30 22	+2 55·75	−3 44·0	10, 10	21 51 20·94	+0·20	+ 7 12 30·1	+7·5	6 (*c*)
26	10 4 32	−1 6·71	+1 50·9	19, 19	21 58 49·16	+0·26	+ 5 26 29·8	+7·6	7
Nov. 7	10 27 53	+0 55·72	+4 55·1	12, 12	22 23 56·72	+0·31	+ 0 49 31·3	+7·6	8 (*d*)
8	9 40 20	−0 41·79	−0 39·8	14, 14	22 26 7·06	+0·24	+ 0 30 14·1	+7·5	9 (*e*)
18	9 41 0	−1 31·08	+5 15·3	14, 14	22 49 38·61	+0·25	− 2 22 33·2	+7·2	10
19	6 19 34	+0 35·33	−7 17·5	18, 18	22 51 45·01	−0·06	− 2 35 6·0	+7·3	10 (*f*)
20	9 28 34	−0 9·42	−1 15·7	20, 20	22 54 31·30	+0·23	− 2 50 59·8	+7·2	11
21	5 56 32	−0 11·59	+2 13·1	15, 15	22 56 37·61	−0·09	− 3 2 39·8	+7·2	12
Dec. 9	6 34 15	+0 27·40	+6 47·6	18, 18	23 42 25·41	+0·01	− 5 45 33·6	+6·5	13 (*g*)
15	6 1 59	+0 28·10	−3 14·5	24, 24	23 57 51·95	−0·02	− 6 9 22·5	+6·2	14
1885. Jan. 7	6 48 36	−1 38·77	+2 9·1	11, 11	0 56 56·14	+0·07	− 5 53 15·0	+5·1	15 (*h*)
	6 48 36	−1 51·78	+3 8·8	11, 11	0 56 56·14	+0·07	− 5 53 17·2	+5·1	16
Feb. 5	6 56 43	+0 43·43	+1 22·7	16, 16	2 8 27·66	+0·10	− 3 9 21·7	+4·0	17 (*j*)

Notes.—(*a*) Sept. 24. Comet has stellar nucleus 2″ or 3″ diam., 9½ mag. Coma perhaps 2′ diameter, no tail. Object glass dewed. (*b*) Oct. 4. Coma 2′ diam.; nucleus 2″; 10 mag. No tail. (*c*) Oct. 22. Fog; object glass much dewed. Observations unsatisfactory. Nucleus distinct, 10 mag. Coma large and faint. (*d*) Nov. 7. Moonlight; some haze. Comet is brighter? (*e*) Nov. 8. Comet bright, 4′ or 5′ diam.; nucleus sub-stellar, 11 mag. Fine night. (*f*) Nov. 19. Comet's diameter about 4′. The central condensation is brighter than it was, and larger, perhaps 4″ or 5″. No signs of tail, but the coma is not uniformly luminous. (*g*) Dec. 9. Diameter 5′. Central condensation about same brightness as before. (*h*) Jan. 7. Comet very much fainter. Nucleus still stellar; getting difficult to observe well. (*j*) Feb. 5. Faint and difficult; diameter 1½ or 2′. Nucleus stellar, glimpsed at intervals. Very fine night.

Mean Places of the Comparison Stars.

	R.A. 1884·0 h m s	s	Decl. 1884·0 ° ′ ″	″		
1	21 18 32·42	+3·39	+20 29 10·4	+30·1	B.B. vi. + 20°·4902	
2	21 18 17·98	+3·38	+20 17 55·4	+30·2	Berlin Zones 1881, 2 obs.*	
3	21 16 43·29	+3·34	+19 18 31·6	+30·2	9-year, 1997.	
	21 16 43·28		+19 18 31·2		Berl. Jahrb.	
4	21 25 11·61	+3·30	+15 50 5·2	+30·1	LL. 41860.	
	21 25 11·43		+15 50 21·3		W.B. xxi. 550.	
	21 25 11·39		+15 50 21·9		Rümker 9228.	
	21 25 11·35		+15 50 17·8		Berlin Zones 1870, 3 obs., adopted.†	
5	21 40 16·48	+3·27	+11 20 28·9	+29·5	LL. 42432	P.M. in decl. −0″·315 has been applied.
	21 40 16·77		+11 20 28·8		W.B. xxi. 936	
	21 40 16·59		+11 20 29·0		Lamont, 2791	
6	21 48 22·05	+3·19	+ 7 15 44·8	+28·6	Lamont, 6182	mean adopted.
	21 48 21·94		+ 7 15 46·1		BB. vi. 4763	
7	21 59 52·36	+3·20	+ 5 24 11·2	+28·0	Piazzi xxi. 390.	
	21 59 53·00		+ 5 24 12·5		W.B. xxi. 1351.	
	21 59 52·67		+ 5 24 10·9		Taylor 10246 (adopted).	
8	22 22 57·76	+3·16	+ 0 44 9·9	+26·1	Lamont, 8848	mean adopted.
	22 22 57·70		+ 0 44 12·6		Harvard Zones 77,5	
	22 22 57·92		+ 0 44 10·3		BB. vi. + 0°·4878	
9	22 26 45·74	+3·17	+ 0 30 27·9	+26·0	LL. 44036.	
	22 26 45·65		+ 0 30 28·1		Lamont, 8879.	
	22 26 45·56		+ 0 30 27·5		Harvard Zones 73,70.	
	22 26 45·68		+ 0 30 27·9		Schj. 9218 (adopted).	
10	22 51 6·53	+3·16	− 2 28 12·6	+24·2	Lamont, 9034.	
		+3·15		+24·1		
11	22 54 37·57	+3·15	− 2 50 8·0	+23·9	W.B., xxii. 1110.	
12	22 56 46·87	+3·15	− 3 5 13·8	+23·7	Lamont, 4700.	
	22 56 46·05		− 3 5 16·6		Peters A.N. 2655 (adopted).	
13	23 41 55·30	+3·15	− 5 52 49·1	+20·2	W.B., xxiii. 821.	
	23 41 55·31		− 5 52 54·4		Rümker 11582.	
	23 41 54·86		− 5 53 1·0		Albany Mer. Obs. A.N. 2657 (adopted).	
14	23 57 20·69	+3·16	− 6 6 27·1	+19·1	W.B., xxiii. 1152.	
	1885·0		1885·0			
15	0 58 35·00	+0·17	− 5 55 24·4	− 5·3	W.B., 0.998.	
	0 58 34·74		− 5 55 18·8		A.N. 2657 (adopted).	
16	0 58 47·75	+0·17	− 5 56 20·7	− 5·3	A.N. 2657.	
17	2 7 44·04	+0·19	− 3 10 35·4	− 9·0	Schj. 649.	

* Kindly communicated by Dr. Becker.

† Kindly communicated by Dr. Auwers.

Five orders of Meteor Streams or Comets. By Richard A. Proctor.

The importance of Mr. Denning's discovery (which must now, I presume, be regarded as established), that the members of certain meteor systems radiate sometimes for months in succession from the same point in the star sphere, induces me to make some remarks upon the subject, with the view chiefly of recommending it to the attention of those who have time for the observation of meteors and shooting stars. I am the more disposed to do this because four or five years ago, when as yet Mr. Denning's discovery was not established, I pointed out the startling inferences deducible from it, as reasons for doubting—at that stage of his observations—whether the discovery could be real. Yet, fully twelve years ago, I had indicated a theory respecting the origin of comets and meteor-systems which would point to the belief that the relations resulting from Mr. Denning's discovery must in reality exist, startling though they are.*

It should not be necessary to state, in addressing the Fellows of the Astronomical Society, that Mr. Denning's discovery can bear but one interpretation. It proves that the motion of the Earth in her orbit round the Sun is almost at rest compared with the velocities of the members of those meteoric families which have an unchanging, or a very slightly changing radiant, for months in succession. Without assuming that the radiants can be determined with anything like the precision claimed by Mr. Denning (noticing indeed that if this were possible, then in the case of some meteor systems the effects even of our Earth's rotation could be detected in a change of radiant during a shower lasting five or six hours), it is certain that we have to deal, in the case of the long-lasting radiants, with bodies travelling at the rate of hundreds of miles per second. This is certain, without taking into account the effects of the Sun's attraction in modifying the direction of the movements of these meteors; but as a matter of fact the Sun's attraction cannot greatly alter (at the Earth's distance) the directions of bodies already moving with velocities far exceeding those he can impart. I have shown this mathematically in recent numbers of *Knowledge*, in which the simple but apparently little known mathematical relations involved have been somewhat fully dealt with.

Another point in Mr. Denning's discovery is also significant in the same direction. The point was not necessary to demonstrate what the discovery unquestionably proves; but it affords very interesting independent evidence. The meteors of the kind considered are seen year after year. Now this, which, in the case of systems observable only for a few hours or days at the outside, is a relation very naturally following from what is already known about such systems, has a very different meaning in the case of these meteors with long-lasting radiants. If the

* In my article on "Three Orders of Comets," *Popular Science Review* for Jan. 1873.

Earth passes one year through a meteor system attending on the Sun, she will pass through it, or at least through its orbit, every year. But meteors of the same system seen several months in succession manifestly cannot belong to a family attending on the Sun. Their being seen many years in succession indicates broad-spreading. It is an independent proof, therefore, of the remoteness of the source from which such meteors originally came.

As the new order of meteors detected by Mr. Denning cannot have been drawn to the solar system by the Sun's action, we must certainly reject in their case what some regard (strangely enough) as the accepted theory of meteoric origin,—I refer to Signor Schiaparelli's speculation that flights of scattered bodies are drawn into the solar system by the Sun's attraction, and are caused by planetary attractions to travel in closed orbits. I showed, twelve years ago, that this speculation undoubtedly fails also in the case of the November meteors, and probably for all meteor systems of that class. It was, however, never more than a speculation, and has always been so regarded by all who understand the matter, including those who have most admired the ingenuity displayed by Signor Schiaparelli in first suggesting, and afterwards enforcing, the theory of the connection between meteors and comets, which is now regarded as an established truth.*

But indeed to account for meteor-systems or comets as drawn from out the interstellar depths, is to explain *obscurum per obscurius*. It is antecedently altogether more unlikely (it is an infinitely wilder hypothesis, one may say) that the immensity of interstellar space should be a sort of breeding place for meteor flights, than that meteors should have had their origin in suns or planets. If an explosion like that of Krakatoa scatters earth-dust through millions of cubic miles of air (here I am in no sense adopting the Krakatoa explanation of the coloured sunsets, but simply referring to what certainly happened), the theory that a sunlike body—our Earth in her youth for instance—has expelled meteoric bodies in occasional eruptions through vast regions of interplanetary spaces, or that a Sun like our own has expelled meteoric bodies through yet vaster regions, is simply a theory which presents on a larger scale what we have already recognised as certainly happening on the smaller scale.

Apart from this, Signor Schiaparelli's speculation, after all, according to which meteor flights came from out the star depths, is by no means inconsistent with any theory showing how the meteor flights may have come into those depths.

Mr. Denning's discovery, since it presents meteor flights, or comets, traversing the interstellar depths with velocities far

* As one of those who most earnestly advocated the recognition extended in 1872 to Signor Schiaparelli's theory, it should hardly be necessary for me to explain that what I have said in regard to his speculation has no reference to the validity of his theory.

greater than our Sun can impart by his attractive might—compels us to recognise something more, in *these* meteor flights, any way, than mere space-begotten bodies. Must we not look for the source of these tremendous velocities, evidence as they are of tremendous energies exerted *somewhere*, to those bodies which are the mightiest we know of,—the giant suns?

In fine, I regard Mr. Denning's discovery as completing the evidence respecting comets which I presented in a comparatively incomplete state in my article on 'Three Orders of Comets,' in the *Popular Science Review* for January 1873. At that time I showed that we can recognise three orders of comets, viz.—*First*, those which, since they travel in paths passing near the paths, severally, of the giant planets, were probably ejected from those bodies when severally in the sunlike state; *secondly*, those which travelling in more widely extended paths, pass so near the Sun that they may be regarded as probably ejected from him, and subsequently so perturbed by planetary action as to pass clear of his globe on their return; and *thirdly*, those whose paths show that they were originally ejected from suns like ours. These three orders must now be regarded as respectively the *second*, *third*, and *fourth orders* of meteor flights or comets. Two other orders must be added, viz.:—*First*, those meteor systems whose paths or component elements show that the meteors were originally ejected from our Earth when she was in the sunlike state; and *fifthly*, those whose enormous velocities show that they were originally ejected, not from suns like our own, but from the giant suns like *Sirius*, *Vega*, *Altair*, and others, whose spectra indicate greater energies than exist in our own sun or his fellows,—as *Capella*, *Aldebaran*, *Betelgeux*, and other suns of Secchi's second class.

All that has been learned from the microscopical, chemical, and physical analysis of meteors, can be explained by the theory to which we have thus been led; and much of it can be explained no other way. Moreover, the observation of the Sun has demonstrated the occurrence of precisely such eruptions as this theory indicates.

To sum up, all or most meteor systems or comets would appear to have had their origin in orbs in the sunlike state, and may be classified under five heads, viz.:

<table>
<tr><td>First, those sprung from the terrestrial planets</td><td rowspan="2">when in the sun-like stage of their career.</td></tr>
<tr><td>Secondly, those sprung from the giant planets</td></tr>
</table>

Thirdly, those sprung from our own Sun.

Fourthly, those sprung from other suns of the same order.

Fifthly, those sprung from the giant suns of the first order.

Other classes probably exist, other sub-divisions certainly.

Galveston, Texas:
1885. *March* 31.

A Peculiar Variety of Meteors. By W. F. Denning.

On the morning of April 20, at 1^h 36^m A.M., while watching the progress of the Lyrids I saw a remarkable meteor, projected apparently on the stars ϵ and δ of *Serpens*, as it rose upwards with great rapidity in the south. The meteor was about the third magnitude, but the singularity about it was its marvellous velocity and seeming nearness. It appeared to be in the air, a few yards distant, and I believe its path, extending (as it instantaneously impressed me) over some 16° on the background of the sky, must have been traversed in less than the twentieth part of a second. Of course there is a great difficulty in estimating such short intervals, but I feel confident the duration was even more transient than that assigned.

Now and then I have observed similar meteors before. They immediately strike one by their close proximity and enormous velocity. They are mere gleams of pale white light, which have little analogy to ordinary shooting stars, and suggest an electric origin, though I do not know whether the marvellous quickness with which they flash upon the eye is not to be held responsible for the sensation of nearness. They are somewhat rare, and one may watch through several whole nights without a single example, but, as far as my memory serves, I must have witnessed some scores of these meteoric flashes. I never register the paths; they are so rapid as to make but a vague impression on the retina, and the direction is necessarily much involved in doubt. As to the meteor of April 20, it ascended in *Serpens* from the western boundaries of *Scorpio*, and probably diverged from a radiant near the bow of *Sagittarius*. It was the only one I saw of the kind alluded to, or which could have belonged to a radiant so low in the S.E. amongst eighty-one meteors recorded during the nights of April 18, 19, and 20, 1885.

I have consulted several catalogues for notices of abnormal meteors such as the one described, but in most cases there is an absence of individual notes, and I have failed to gather much evidence of the kind required. But a most excellent instance, and I think the only one, is referred to in Col. Tupman's catalogue of nearly two thousand shooting stars observed by him while cruising in the Mediterranean during the years 1869–71. The particulars are:—

1870, January 9, 14^h 59^m; mag. 3; path from $169°+20°$ to $157°-10°$; length 31°; duration 0·1 second. "An instantaneous flash; seemed to be in the air, quite near. Very curious."

It will be seen that Col. Tupman's description is very similar to my own. Though his meteor had a path of no less than 31°, he estimated the duration as only the tenth of a second.

On the whole I incline to the belief that meteors of this abnormal class give the idea of great nearness as the result of their astonishing speed, and that they will be invariably found

directed from radiants close to the Earth's apex. Their appearance, however, is such as to vividly impress the observer as to their special character. It therefore seems desirable to mention the circumstances, so that workers in this department may record such further instances as they may notice, notwithstanding the uncertainty attached to the path directions of such very transient phenomena. It is just possible they may indicate a form of meteoric display essentially different to that commonly understood.

Bristol: 1885, *April* 27.

Observing Weather. By Rev. S. J. Johnson.

In the last report of U.S. Naval Observatory, Washington, it is stated (p. 9): "A record has been kept by the various observers and the watchmen of the condition of the sky as regards seeing. From this, it appears that but 126 nights were clear enough for observing, and of these but 38 are recorded as good, the remaining 88 being poor or indifferent." For the last quarter of a century I have recorded the number of evenings fit for observation in the western parts of England. In this respect we appear somewhat less favoured than the Americans. By evenings fit for observation, it is inferred that the sky was clear, or with a few small passing clouds, till about 11^h, or else thoroughly clear for a full hour. Clearness of the atmosphere alone is regarded in the following list, not suitability for dividing very close double stars.

The number of nights was as follows:—

In 1859 =	60	nights.	In 1868 =	62	nights.	In 1877 =	60	nights.
1860	44	"	1869	58	"	1878	86	"
1861	46	"	1870	112	"	1879	71	"
1862	46	"	1871	98	"	1880	96	"
1863	47	"	1872	90	"	1881	110	"
1864	83	"	1873	82	"	1882	90	"
1865	82	"	1874	113	"	1883	101	"
1866	77	"	1875	100	"	1884	100	"
1867	55	"	1876	115	"			

To give each separate month would occupy space, but it may be stated that the number of clear nights varied from 18 in August 1870 and 17 in May 1876, to one night only in September 1866 and January 1869.

Melplash Vicarage,
Bridport: April 7.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. JUNE 12, 1885. No. 8

EDWIN DUNKIN, F.R.S., President, in the Chair.

Rev. Thomas Perkins, M.A., The School, Shaftesbury, Dorset, was balloted for and duly elected a Fellow of the Society.

On some Points of Difference between the Harvard and Oxford Stellar Photometry. No. 1. By Prof. C. Pritchard., D.D., F.R.S.

The second part of the *Harvard Photometry* recently published contains, among many other subjects of interest, a very elaborate series of comparisons of the magnitudes of stars as estimated or measured by a great variety of astronomers. Among these is a comparison between the photometric measures made at Harvard with the Meridian Photometer and those made with the Wedge Photometer at Oxford. Such comparisons of catalogues may possess a very great scientific value.

In the course of the above inquiry, and as one result of the comparison referred to, the following passage occurs: * "The results derived from the Wedge Photometer should theoretically be affected by the brightness of the background, and this effect appears actually to occur in the present instance," *i.e.* in the catalogue of photometric magnitudes published in vol. xlvii. of the *Memoirs* of the R.A.S., but which, it is important to observe, forms but a small part of the completed work.

I confess that these statements greatly surprised me, because from the very first application of the method to its final completion I had watched the progress of the work with a scrupulous and jealous care, lest some systematic error might after all lurk either in the principles of the instrument or in the mode of its use. In particular I had considered any possible effects arising

* *Harvard Photometry* ("Annals of Harvard College Observatory," vol. xiv.), p. 493.

from the varying brightness of the background against which the stars were apparently projected, and specially I felt it necessary to be *practically* assured (irrespective of any theory) that even bright Moon light, or the total absence of the Moon from the sky, produced no sensible effects on the determination of relative magnitude. If such be the case (as it in reality is) with bright Moon light, then the slighter variations of the background arising from variations in stellar density (the form in which the objection is made) might reasonably be expected, *a fortiori*, to be harmless. Nevertheless, I have also *practically* assured myself that such is the case as to the observations themselves.

First, with regard to the effects of Moon light on the point of extinction of any particular star. During the three years through which the observations extend, *Polaris* has been extinguished many thousand times. Accordingly I have divided these extinctions into four periods, corresponding to the four phases of the Moon, and, as a result, I find that whatever may have been the phase, the mean point of wedge-extinction of *Polaris* remains sensibly the same. This will be rendered evident by an inspection of the following table.

Point of Wedge-Extinction of Polaris in reference to the Moon's age.

Moon's Age.	Mean Wedge reading for Extinction.	No. of Extinctions.
d d	inches	
0– 7	4·77	1050
7–14	4·76	1125
14–21	4·74	1675
21–28	4·75	1275

In the foregoing table, column one gives the Moon's quarterly phase, during which the extinctions were made. The second column gives the mean reading in inches, measured from the extremity of the wedge, of the point of extinction. The last column gives the number of extinctions employed in obtaining the mean. The observations in question were made with one wedge applied to a telescope of 4 inches aperture. Similar observations in number and principle were also made with an aperture of 2 inches; and again, with another wedge and another telescope of 3 inches and 1½ inch aperture. It is only necessary to add that a variation of one-hundredth of an inch in the wedge reading, implies a variation of one-fiftieth of a magnitude.

I come next to the less salient case of a varying brightness of the field, arising from varying stellar density in different portions of the sky, and the question here arises, "Is it a fact that the Oxford results depend, to any extent, on the brightness of the field" * as arising from this cause? The implication here made is, after all, indefinite in amount, and possibly necessarily

* *Harvard Photometry*, p. 502.

so, owing to the extremely small number of measures then published in some of the groups. Be this as it may, in the *Harvard Photometry* the heavens are divided into thirty-six portions of approximately equal area, and the corresponding stellar densities in each of these are tabulated as obtainable both from the *Harvard Photometry* and the more extended tables of the *Durchmusterung*. The results of the *Harvard Photometry* are then practically assumed as a Standard, and the mean deviations of the Oxford results from the Harvard results in each of the thirty-six divisions are tabulated,* and then, as a final result, the conclusion given above is drawn.

The three densest portions of the sky are designated as B_8, C_3, C_{10}; that is approximately the regions of *Cygnus*, *Taurus* and *Orion*, and *Aquila* respectively. If, then, the systematic error attributed exists, we should expect to find it most pronounced by deviation from the Standard in these regions; but in point of fact the deviations from the Standard in the region B_8 stand, not first, but fourth, in numerical order; and in the other two, C_3 and C_{10}, the deviations from the assumed Standard are inconspicuous and singularly small. On the other hand, where the deviations from the Harvard Standard are most pronounced, viz. in D_5, D_3, C_4 (viz. in *Hydra*, *Monoceros*, and *Canis Minor*), the sky is in D_5 and C_4 below the average of brightness; the region D_3 is slightly above the average stellar density. From this investigation I cannot avoid the conclusion that there is no sufficient ground (from the data published) for suggesting the existence of a systematic error in the *Oxford Photometry* from the cause referred to. On an examination of the *whole* Oxford Catalogue, now on the eve of publication, and containing a large number of the fainter stars, where the effect would be greatest (if any), I find still stronger grounds for denying the existence of any such small systematic error as the one referred to.

Lastly, in the *Harvard Photometry* a systematic error is suggested as existing *generally* in catalogues of magnitude, depending upon the magnitude of the stars. I cannot say whether the Oxford measures are included in this suggestion or not. That it does exist in estimations made by the unaided eye is, I think, very probable; and, in fact, it was long ago suggested as natural and even proper by Sir John Herschel, but upon a very elaborate examination of the 3,000 stars contained in my completed catalogue, I have found not the slightest trace of any systematic deviation of measure, when compared with the Harvard Catalogue, due to the brightness of the objects measured.

As a final result of these investigations I claim on behalf of the wedge photometer that no systematic error exists, either in relation to the varying brightness of the field of view or to the brightness of the stars themselves.

It will be remarked that the inquiry as to the influence of

* *Harvard Photometry*, p. 490.

variable stellar density on the Oxford Photometry, depends solely on a comparison of the Oxford work with the Harvard Catalogue, taken as the Standard of reference. It appears, therefore, to me to be a matter of scientific importance herein, to institute some investigation regarding the amount of reliance which is to be placed on the accuracy of the magnitudes assigned to single stars in the Standard itself; and this investigation can be made alone by means supplied in the published volume. Now, by far the greater number of the Harvard adopted magnitudes is derived from the mean of separate determinations made on *three* different nights. The residuals of these three determinations from the adopted mean magnitude are given in the General Catalogue, Table xxvii. That these three residuals inadequately express the amount of exactness of the adopted mean magnitude, appears from the following considerations. In many instances a much greater number of measures of magnitude is given, obtained on many different nights, sometimes extending to as many as fifteen or twenty. *Sirius*, *Arcturus*, &c., are instances of this. It is from these numerous measures that we can obtain some indication of the reliance which is to be placed on a determination derived from three only. By way of illustration, a fair criterion of the value of transit observations (simply considered as transits) may be derived by comparing the adopted mean obtained from observations over nine wires, with the results obtainable from those over any three of the wires.

If this sort of test be applied to the *Harvard Photometry*, notable differences in the magnitude of the same star will be found to occur with frequency. The measures derived from *three* successive nights are taken, because it is from the measures of three successive nights alone, that the vast bulk of the magnitudes in the Catalogue is derived, provided only no suspicious circumstances have occurred during the three said successive nights. As an example, and for the sake of clearness, take the observations of *Sirius*, No. 1275, Table xxvii. They are sixteen in number. The adopted magnitude is −1·43. Now, if the magnitude of *Sirius* had been derived from the third, fourth, and fifth nights of observation alone, it would differ from the finally adopted magnitude by ·33 mag.; and if the measures on the sixth, seventh, and eighth nights only be taken, the magnitude would differ by ·30 *in the other direction*, *i.e.* there would be a difference of six-tenths of a magnitude between the two results, and no suspicious circumstance is recorded as having attracted the attention of the observer, except, perhaps, in the third series. This seems to indicate that great exactness cannot be necessarily conceded to the Meridian Photometer, when observations are limited to three nights only. Further still, there are instances in which a magnitude derivable from even as many as seven successive nights, sensibly differs from the finally adopted magnitude. The measures of ε *Orionis*, *Pollux*, &c., will be found

to support this statement, even among the few stars comprised in the subjoined table.

The following table has been constructed on the principles indicated above, and it applies to all the brighter stars visible in the northern heavens, from *Sirius* down to stars comparable in lustre with *Polaris*.

Variations in the magnitude of the bright stars, from Sirius to Polaris, as derivable from any three successive concluded measures of magnitude in the Harvard Photometry, "H. P."

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Nights.
Sirius	−1·76	−1·13	0·63	−1·43	16
Arcturus ...	−0·20	0·36	0·56	0·03	13
Capella ...	0·08	0·31	0·23	0·18	16
Rigel	0·15	0·42	0·27	0·32	15
α Lyræ ...	0·09	0·36	0·27	0·19	15
Procyon ...	0·36	0·76	0·40	0·46	15
α Orionis ...	0·81	1·08	0·27	0·91	10
Aldebaran ...	0·80	1·17	0·37	1·00	16
α Aquilæ ...	0·64	1·14	0·50	0·97	15
Antares ...	0·89	1·23	0·34	1·06	13
Spica	1·06	1·63	0·57	1·23	13
Pollux	0·75	1·39	0·64	1·12	15
Fomalhaut ...	1·09	1·46	0·37	1·26	16
Regulus ...	1·29	1·52	0·23	1·42	15
α Cygni ...	1·20	1·77	0·57	1·47	13
ε Canis Maj. ...	1·22	1·72	0·50	1·49	17
Castor	1·26	1·69	0·43	1·56	15
γ Orionis ...	1·73	2·13	0·40	1·86	16
ε Orionis ...	1·56	1·89	0·33	1·76	16
ζ Orionis ...	1·62	2·12	0·50	1·89	15
β Tauri ...	1·80	2·13	0·33	1·90	15
η Ursæ Maj. ...	1·75	2·12	0·37	2·02	13
λ Scorpii ...	1·48	1·91	0·43	1·68	6
ε Ursæ Maj. ...	1·52	2·02	0·50	1·85	13
α Ursæ Maj. ...	1·86	2·06	0·20	1·96	15

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Nights.
α Persei ...	1·77	2·04	0·27	1·94	19
β Aurigæ ...	1·90	2·37	0·47	2·07	14
δ Canis Maj. ...	1·65	1·98	0·33	1·85	15
θ Centauri ...	1·70	1·86	0·16	1·73	6
α Androm. ...	1·85	2·31	0·46	2·08	16
Polaris ...				2·15	
γ Geminor. ...	1·83	2·10	0·27	2·00	17
β Canis Maj. ...	1·84	2·18	0·34	2·01	15
α Hydræ ...	1·85	2·22	0·37	2·02	15
α Arietis ...	1·91	2·21	0·30	2·04	19
ζ Ursæ Maj. ...	2·18	2·51	0·33	2·38	13

In the above table the second column contains the least magnitude of the particular star, as derived from any three consecutive residuals and the finally adopted magnitude given in the general catalogue of the *Harvard Photometry*. The third column is the greatest magnitude derived in a similar manner. The fourth column contains the range of magnitude deduced from the foregoing consecutive combinations. The fifth column contains the magnitude ultimately adopted, and the sixth the number of nights on which the successive measures were made.

Some explanation of the serious discrepancies thus disclosed by the preceding table, and beyond my own power now to give, seems very desirable.

In a short time from the present date the whole of the Oxford work will be published by the University, under the title of *Uranometria Nova Oxoniensis*; and it will then be my duty to compare its results with any other catalogues of a similar nature. At present, one further remark alone remains to be made. Whatever may be the criticisms to which the particular works completed at Harvard College and at Oxford may be fairly open, one thing appears to be certain—namely, that the application of Photometry to the determination of stellar lustre has made an enormous advance over the ancient methods of estimates by the unaided eye. Guided by the experience of some seventy thousand extinctions of stars made with the Wedge Photometer, I feel certain that on any single fair night, the apparent difference of the magnitudes of any two stars may be ascertained within the limits of an error not exceeding the tenth of a magnitude. I conclude with the expression of the hope that no remark made in the course of the present inquiry will be deemed as inconsistent with unfeigned respect for the remarkable ingenuity and unremitting labour which characterise every page of the *Harvard Photometry*.

On Al-Sūfi's Star Magnitudes. By E. B. Knobel.

In vol. xiv. of the "Annals of Harvard College Observatory," Prof. Pickering has drawn attention to some alleged differences between the magnitudes of Ptolemy's stars as given by Al-Sūfi in his "Description of the Constellations," and by Ulugh Beigh in his Catalogue. These discrepancies are given on the authority of Dr. C. H. F. Peters, who has published in the *Astronomische Nachrichten*, xcix. 235, a list of 74 differences which he finds in comparing Schjellerup's translation of Al-Sūfi with Hyde's translation of Ulugh Beigh.

As Prof. Pickering has given a table entitled "Differences between Sūfi * and Ulugh Beg," we might be led to infer that Ulugh Beigh had really made some estimations of star magnitudes, and in that case the question would deserve investigation.

The only information we possess as to the construction of Ulugh Beigh's Catalogue of Stars is contained in his Preface to the Catalogue, which has been translated into Latin by Hyde, and into French by Sédillot, and forms chapter xiii. of the Third Part of his "Prolégomènes des Tables Astronomiques d'Oloug-Beg." The chapter is short, and as Sédillot's work is rather scarce, I beg to transcribe it.

"Avant Ptolémée on avait observé 1022 étoiles fixes; Ptolémée les a placées dans un catalogue inséré dans *l'Almageste.*

"On a distribué ces étoiles en six grandeurs; les plus grandes sont de la première grandeur, et les plus petites de la sixième grandeur.

"On a aussi établi trois ordres dans chaque grandeur, et pour reconnaître les étoiles on a imaginé 48 Figures ou Constellations, dont 21 sont au nord de l'écliptique, 12 dans le zodiaque, et 15 au midi.

"La plupart des étoiles sont dans les figures mêmes; les autres sont aux environs, et on les désigne par le nom d'externes de la constellation.

"Abderrahman Soufi a composé un Traité des étoiles que tous les savants ont reçu avec empressement.

"Avant de determiner par nos propres observations le lieu de ces étoiles nous les avons fait disposer sur des sphères d'après ce Traité et nous les avons trouvées pour la plupart placées différemment qu'on ne le juge à l'inspection du ciel.

"Cela nous a déterminé à les observer nous-mêmes avec le secours de la protection Divine et nous avons réconnu qu'elles étaient avancées en raison de l'époque à laquelle l'ouvrage a été composé, de sorte qu'en leur donnant selon cette observation

* This author is erroneously called "Sūfi" in modern works. His correct name appears to be Abd-al-Rahman Al-Sūfi (pronounced Abdurrahman Assūfi). That is to say, Abd-al-Rahman *the* Sūfi, because he belonged to the old and existing religious sect of the Sūfies. It seems, therefore, incorrect to call him simply Sūfi.

générale, la position absolue qui leur convient, nous n'avons plus trouvé la différence qu'elles présentent à l'œil.

"C'est d'après ce principe que nous avons réobservé toutes les étoiles déjà déterminées à l'exception toutefois de vingt-sept qui ne sont pas visibles à la latitude de Samarcande à cause de son grande éloignement du midi : savoir, les sept de la figure de l'Encensoir (*Ara*), huit dans le Navire de la 36me à la 41me et les 44me et 45me ; onze dans le Centaure depuis la 27me jusqu'à la dernière, et une, la 10me, dans la constellation du Loup ; et nous avons pris ces vingt-sept étoiles dans le livre d'Abderrahman Soufi en tenant compte de la différence de l'époque (de son catalogue et du nôtre).

"En outre il y a huit étoiles dont Abderrahman Soufi fait mention dans son livre comme ayant été placées en leur lieu respectif par Ptolémée, mais que lui Abderrahman n'y a pas vues et que malgré toutes nos récherches nous n'avons pu nous-mêmes découvrir ; c'est pourquoi nous n'indiquons pas ces étoiles dans le présent catalogue : ces étoiles de Ptolémée sont la 14me du Cocher (*Auriga*), la 11me du Loup et les six externes du Poisson Austral.

"Nous établissons dans notre catalogue le lieu des étoiles pour le commencement de l'année 841 de l'Hégire afin qu'en tel temps qu'on voudra on puisse retrouver le lieu de chacune dans la supposition qu'elles avancent d'un degré en 70 années solaires."

As Ulugh Beigh based his catalogue upon that of Al-Sūfi, and makes no mention of any observations of the brightness of the stars, it is not unreasonable to infer that the magnitudes he gives are simply copied from Al-Sūfi, and in that case the alleged "differences between Sūfi and Ulugh Beg" can be nothing more than differences in the MSS., due to transcribers and translators.

It may be mentioned at once that two of the alleged differences are in the case of the 29th and 31st stars in *Centaurus*, which Ulugh Beigh particularly states are not visible at the latitude of Samarcand, and which he therefore copied from Al-Sūfi.

In the *Monthly Notices* for 1879 (vol. xxxix.) I have given a complete translation of the star magnitudes in the Persian MS. of Ulugh Beigh belonging to the Society, and I have shown that this MS., compared with the two editions of Hyde's translation from Oxford MSS., contains 158 different readings. Forty-eight of the supposed differences with Al-Sūfi are here found to have no existence.

Great interest attaches to the description of the constellations and the undoubtedly original estimations of star magnitudes by Al-Sūfi, which makes it worth while investigating all available MSS.

With this object I have examined two Arabic MSS. of Al-Sūfi's "Description of the Constellations," one at the British Musem (Additional MSS. 7488), and the other in the India Office Library (Arabic MS. 2389), which, through the kindness of the Secretary of State, has been lent to me.

Unfortunately, neither of these MSS. is complete. That at the British Museum is of the fifteenth or sixteenth century—well and clearly written, and the drawings of the constellations beautifully executed. The catalogue of the stars in *Equuleus*, *Canis Major*, and the *Informatæ* of *Piscis Australis*, are omitted.

The India Office MS. is probably of a later date. It can be considered only as a fragment, inasmuch as it does not contain the catalogues of *Ophiuchus*, *Serpens*, *Sagitta*, and *Canis Major*, nor the descriptions of *Serpens*, *Sagitta*, and *Aquila*; and the MS. terminates with the description of *Argo*; wanting therefore the catalogue of *Argo*, and the descriptions and catalogues of *Hydra*, *Crater*, *Corvus*, *Centaurus*, *Lupus*, *Ara*, *Corona Australis*, and *Piscis Australis*.

The value of a MS. of Ptolemy or Al-Sūfi depends largely upon the care and accuracy with which the subdivisions of the star magnitudes are indicated. In the Greek *Almagest* these are expressed by the words μείζων and ἐλάσσων appended to the magnitude. In the Latin *Almagest*, translated from the Greek by Trapezuntius, by "ma" (major) and "mi" (minor). In the Liechtenstein Latin *Almagest*, translated from the Arabic by Gerard of Cremona, by "em" (presumably for μείζων) and "el" (ἐλάσσων). In the British Museum Arabic *Almagest* of A.D. 1218, by the Arabic letters mīm م and lām ل. (These two last examples suggest that the original Arabian scribe, who translated from the Greek, had no idea of the meaning or the application of the words μείζων and ἐλασσων, and therefore appended the initials of the Greek words in Arabic letters). In the Bodleian Library Arabic *Almagest* and the several MSS. of Al-Sūfi and Ulugh Beigh, these subdivisions are expressed by the letters Kāf and Sād, being the initials of the words كبير (large) and صغير (small). Thus γ μείζων, 3 ma, 3 em, جم, جك, all express that the magnitude is 3–2.

In the oriental MSS. I have examined, great care has always been taken by the scribes in ruling the necessary columns for entering the catalogues of stars; but in all cases, the last column is ruled only wide enough to insert the number expressing the magnitude, rendering it necessary for the qualifying letters, which indicate that the magnitude is either a large or a small one, to be written in the margin. And as the majority of the magnitudes are without such letters, there is nothing to indicate to the scribe that they are omitted, and so hardly any MS. appears to give the whole series complete.

In the British Museum MS. of Al-Sūfi very many of the initial letters referred to are omitted. From the constellation *Argo* (where there are indications of a change in the writing) to the end of the MS. they are entirely omitted.

In the India Office MS. they are omitted altogether from beginning to end.

Notwithstanding these imperfections, I think it may be interesting to compare the differences between these MSS. and those translated by Schjellerup. I therefore submit a table showing the different readings I have found; and I think that there are enough variations in the MSS. to indicate that we cannot feel sure that we yet possess a sufficiently perfect edition of Al-Sūfi's star magnitudes to warrant the assumption that any differences between him and the Ulugh Beigh MSS. may be due to original observations by the Samarcand astronomer.

In the following table the first column gives Ptolemy's number of the star in the constellation. In the second column the magnitudes in the British Museum and India Office MSS. of Al-Sūfi, indicating the latter by the letters I.O. This MS. being devoid of letters qualifying the magnitudes, I give only those cases which are entirely discordant with the other texts. The third column gives the magnitudes in Schjellerup's *Tableau Synoptique.*

Al-Sūfi's Star Magnitudes.

Differences in the following Arabic MSS.:—
British Museum. Add. MSS. 7488 = Brit. Mus.
India Office MS. 2389 = I.O.
St. Petersburg MS. / Copenhagen MS. } examined by Schjellerup = Schj.

Constellation	No.	Brit. Mus.	Schj.
Ursa Minor	5	5	5–4
Draco	5	3 3 I.O.	2–3
	10	3 3 I.O.	4
	11	4–5 4 I.O.	3–4
	16	5	5–4
	19	4	4–3
	27	3	3–4
	28	5	5–4
	29	3	3–4
	30	3	3–4
	31	3	3–4
Cepheus	1	4	5–4
	3	4	4–3 3–4
	8	4 5 I.O.	4–3
	11	4 6 I.O.	6
Boötes	1	5	5–4
	2	5	5–4
	3	5	5–4
	18	4	4–3
Corona	3	4	4–5
Hercules	13	5	5–6 6–5
	14	5	5–6 6–5
	15	4	4–3
	25	4	4–3
Lyra	2	4	4–3
	3	4	4–3
	4	4	4–3
	5	4	4–5
	6	4	4–5
	7	3	3–4
	8	4	4–5
	10	5	5–6
Cygnus	1	3	3–4
	2	6	6–5

Constellation.	No.	Brit. Mus.	Schj.
Cygnus	4	3	3–2*
	7	4	4–5
	10	4 3 I.O.	3
	11	4	4–5
	12	4 3 I.O.	3
	15	4	4–3
Informatæ	1	4	4–3
Cassiopea	1	4	4–3
	4	3	3–2
	7	4	4–5
	8	4	4–5
	11	4	4–5
Perseus†	3	3	3–4
	4	4	4–5
	12	2	2–3
	13	4	4–5
	14	4	4–3
	25	3	3–4
	26	3	3–4
Informatæ	1	5	5–6
	2	5	5–6
Auriga	10	3	3–4
Ophiuchus	2	3	3–4
	5	4	4–3 3–4
	8	3	3–4
	9	5	5–4
	10	4	4–3
	13	4	4–5 5–4
	14	4	4–5 5–4
	15	4	4–3
	16	4	4–5
	18	5	5–6

Constellation.	No.	Brit. Mus.	Schj.
Serpens	2	4	4–5
	3	3	3–4
	4	3	3–4 3
	6	4	4–5
	7	3	3–4
	8	3	4
	10	3	3–4
	14	4	4–3
	17	4	4–3
Aquila	2	3	3–4
	3	2	2–1
	9	5 3 I.O.	3
Informatæ	1	3	3–4
	3	3	3–4
	4	4	4–5
	6	3	3–4
Delphinus	1	4	4–3
	4	3	3–4
	5	3	3–4
	6	3	3–4
	7	3	3–4
Pegasus	1	2	2–3
	2	2	2–3
	3	2	2–3
	4	2	2–3
	13	5–6 5 I.O.	5–6 6
	14	5–6 5 I.O.	5–6 6

Enumeration in I. O. MS. gives four stars of mag. 3 and four of mag. 5. Schj. gives three of mag. 3 and five of mag. 5.

Constellation.	No.	Brit. Mus.	Schj.
Andromeda	9	4–5	4–3
	14	4	4–5

* Mag. 3 in Catalogue.

† In Schjellerup's enumeration of the stars there is an error: for "une de la sixième" read "une nébuleuse."

Constellation.	No.	Brit. Mus.	Schj.
Andromeda	17	4	4-3
	18	4	4-3
	21	5-6 5 I.O.	5-6 6-5
	22	5-6 5 I.O.	5-6 6-5
Triangulum	3	5	5-6
	4	3	3-4
Aries	12	5 4 I.O.	5

Enumeration, I. O. MS. gives five of mag. 4 and five of mag. 5. Schj. gives four of mag. 4 and six of mag. 5.

Constellation.	No.	Brit. Mus.	Schj.
Informatæ	1	3-4	3-2
Taurus	8	4 5 I.O.	4-3
	10	4-3	4
	23	4	5
Informatæ	6	6	6-7
Gemini	7	4-5	4-3
	9	5	5-4
	10	3	3-4
	15	3-2 4 I.O.	4-3
	16	3	3-4
	17	3-2	3
	18	4-5	4

Enumeration, I. O. MS. gives five of mag. 3 and nine of mag. 4. Schj. gives six of mag. 3 and eight of mag. 4.

Constellation.	No.	Brit. Mus.	Schj.
Gemini Informatæ	1	4-5	4-5 5-4
	4	6 I.O.	5-6
	5	6 I.O.	5-6
	6	6 I.O.	5-6

Enumeration, I. O. MS. gives one of mag. 5 and three of mag. 6. Schj. gives four of mag. 5 and none of mag. 6.

Constellation.	No.	Brit. Mus.	Schj.
Cancer	3	4-5	4-5 5-4
	8	4 5 I.O.	5-6 6-5
	9	4-5	4
Informatæ	1	4	4-5
	2	5	4-5
Leo	3	3	3-4
	4	3	3-2
	13	4	4-3
	19	5	5-4
	23	3	3-4
	24	4	4-3
Informatæ	3	4	4-5
Virgo	11	5	5-6
	14	1	1-2
	15	3	3-4
	16	5	5-6 6-5
	18	5	5-6
	19	5	5-6 6-5
	20	5	5-6
	25	4-5	4
	26	4	4-3
Informatæ	5	6 5 I.O.	5
Libra	2	5-6	5-6 6-5
	4	5-6	5-6 6-5
	5	4-5	4
	6	5	5-6 6-5
Scorpio	4	3-4	3-4 4-3
	7	3	3-4
	16	3	3-4 4-3

Constellation.	No.	Brit. Mus.	Schj.
Scorpio	18	3	3–4
	21	3	3–4
Informatæ	1	4	4–5
Sagittarius	7	4	4–3
	11	4	4–3*
	16	5	5–6
	18	5	5–6
	19	4	4–5
	20	5	5–6
	21	4	4–3
	23	4	4–5
	24	4	4–5
	25	3	3–4
	26	4	4–5
	27	4	4–5

Enumeration, I. O. MS. gives seven of mag. 3 and thirteen of mag. 4. Schj. gives six of mag. 3 and fourteen of mag. 4, not accordant with the magnitudes in the Catalogue.

Constellation.	No.	Brit. Mus.	Schj.
Capricornus	2	6 I.O.	5–6
	4	6	—†
	11	6 I.O.	4
	14	4	4–5
	15	5	5–4
	16	4	6
	17	4	6
	18	4	5–6
	20	3	4
	21	3	4
	22	3	4–5
	23	3	3–4
	25	4	5–6

Enumeration, I. O. MS. gives seven of mag. 3, four of mag. 5. Schj. gives four of mag. 3 and seven of mag. 5.

Constellation.	No.	Brit. Mus.	Schj.
Aquarius	1	6	6–7
	2	3	3–4
	4	3	3–4
Aquarius	7	5	5–6
	8	4	4–3
	9	3	3–4
	10	4	4–3
	11	3	3–4
	12	3	3–4
	14	5	5–6
	15	4	4–5
	16	4	{4–5 {5–4
	17	4	6
	21	{5–6 {6 I.O.}	5–6
	29	5–6	4
	30	5	5–6
Pisces	1	4–5	4
	16	4	4–5
	17	4–5	4
	19	3–4	{3–4 {4–3
	22	3	{3–4 {4–3
	25	5	{5 {4
	26	6	6–7‡
	27	6	6–7‡
	28	6	6–7‡
	31	4	—§
Cetus	16	3	3–4
	19	5	{5–6 {6–5
	20	5–6	{5–6 {6–5
Orion	12	5	5–6
	16	5–6	5
	24	3	3–4
	29	3	3–4
	31	3	3–4

* Mag. 4 in Catalogue.
† Mag. 6·7 in Catalogue.
‡ Mag. 6 in Catalogue.
§ Mag. 4 in Catalogue.

Constellation.	No.	Brit. Mus.	Schj.
Orion	35	1–2	1
	36	4	4–3
	38	3–2	3–4*
Eridanus	1	4 6 I.O.	4
	3	4–5	4–5 5–4
	12	3–4	3–4 4–3
	17	5–6	5–6 6
	19	4	4–5
	20	4	4–3
	24	5	5–6
	27	4	4–5
	30	4	4–3
	34	4† 1 I.O.	1
Lepus	9	4–5	4–3
	10	4–5	4–3
Argo	3	4	4–3
	5	5	5–6
	6	4	4–3
	10	4	4–5 5–4
	11	5	5–6
	25	4	4–3
	26	4	4–3
	27	3	4
	28	3	4
	29	4	4–5 5–4
	30	4	4–5 5–4
	33	4	4–3
	36	3	4
	41	4	4–3

Constellation.	No.	Brit. Mus.	Schj.
Argo	42	5	4
	43	3	3–4
	45	3	3–4
Hydra	1	4	4–5
	4	5	4
	5	4	4–3
	8	4	4–5 5–4
	9	4	4–5
	10	4	4–5
	11	6	6–7
	13	5	4
	15	4	4–3
	16	3	3–4
	17	4	4–5
	18	4	3
	21	3	4–3
	22	3	4
	24	3	3–4
	25	4	3–4
Crater	4	5	5–6
	5	4	4–5 5–4
	6	4	4–5
	7	4	4–5
Corvus	1	3	3–4
Centaurus	8	4	4–5
	12	4	4–3
	13	4	4–3
	15	4	4–3
	17	4	4–3
	21	4	5
	25	5	5–4
	28	5	5–6 6–5
	30	omitted	omitted
	33	3	3–4

* Mag. 3 in Catalogue.

† An obvious error. I am not aware of any other instance of *Ultima Fluvii* not being mag. 1.

Constellation.	No.	Brit. Mus.	Schj.	Constellation.	No.	Brit. Mus.	Schj.
Centaurus	36	2	2–1	Ara	3	4	4–3
	37	4	4–5		4	5	5–6, 6–5
Lupus	3	4	4–3		5	4	4–5
	4	3	4	Cor. Australis	5	5	5–6
	5	4	4–3		8	6	5
	10	4	4–5		9	5	6
	11	omitted	omitted		10	5	6
	12	4	4–5		11	6	5–6
	16	5	5–4		12	5	5–6
	17	6	5–6, 6–5	Pisc. Australis	6	6	5–6
	18	6	6–7		9	5	5–4
	19	5	5–6		11	3	3–4

1885, *June* 11.

Observations of the Satellites of Saturn and of the Companion of Sirius, made at the U.S. Naval Observatory, Washington. By Professor Asaph Hall, U.S.N.

(*Communicated by Commander A. D. Brown, U.S.N., Superintendent.*)

Conjunction of the Satellites of Saturn.

Mimas.

Date.	Wash. M.T. h m	Position.	Weight.	Remarks.
1884, Sept. 22	15 57·6	S.	3	

Enceladus.

Date.	Wash. M.T. h m	Position.	Weight.	Remarks.
1884, Sept. 22	15 48·6	S.	3	
Oct. 25	13 1·7	S.	2	
1885, Jan. 29	10 22·1	S.	3	
Feb. 16	5 51·7	S.	2	Extremely faint.
18	7 9·8	N.	2	Hazy. Satellite very faint.
20	8 34·1	S.	3	
Mar. 3	7 40·4	S.	3	
14	6 40·7	S.	3	Hazy.

Tethys.

Date.	Wash. M.T. h m	Position.	Weight.	Remarks.
1884, Sept. 23	17 29·7	S.	3	
Nov. 16	12 21·1	N.	3	

Date.		Wash. M.T.	Position.	Weight.	Remarks.
1885, Jan.	8	8 24·9	N.	3	
	26	6 46·1	S.	2	Poor images.
Feb.	10	9 11·0	S.	2	Very windy and telescope shaken.
	11	7 44·6	N.	3	
	12	6 38·0	S.	4	
	28	7 42·2	N.	2	Somewhat hazy.
Mar.	17	7 33·8	N.	3	

Dione.

1884, Sept.	26	15 57·8	S.	3	Cloudy.
Dec.	16	8 51·2	N.	2	
1885, Jan.	26	9 33·1	N.	2	Poor images.
Feb.	6	8 17·0	N.	3	
	17	7 3·7	N.	2	Very unsteady.

Rhea.

1885, Jan.	2	8 17·2	S.	3	
	29	10 21·1	S.	3	
Feb.	23	6 31·1	N.	3	

Observations of the Companion of Sirius.

Date.	Sid. T.	p	s	Weight.	Remarks.
	h		"		
1885·219	6·6	36·3	7·96	2	Very faint.
·233	6·8	35·2	8·23	2	Faint.
·235	7·0	35·6	8·17	2	Faint.
·252	7·3	36·3	—	2	Very faint; hazy.
·293	8·7	34·4	—	2	Very faint; haze.
·301	8·8	33·9	7·93	4	Double weight.
·304	9·0	33·8	8·22	2	Very faint.
·307	9·1	33·2	7·96	2	Faint.

Mean Results.

	p	s
1885·268	34·73	8″·057

Remarks.—The preceding conjunctions of the satellites of *Saturn* were observed by placing the micrometer wires perpendicular to the major axis of the ring by means of the angle given in the *American Ephemeris* for 1884 and 1885, pp. 465, 479. On March 5, 1885, *Mimas* was seen very distinctly when it was just past north conjunction. This satellite was about two-thirds the distance from the centre of the ball to its edge at $6^h\ 45^m$ M.T.

Mimas was remarkably bright, and could not be missed even when the full light of the planet was admitted to the eye. Generally this satellite is a difficult object, and from the ease with which it is occasionally seen one might think it variable; but I think the difference is due to the quality of the images. On this night the images were excellent for a short time, and *Mimas* and *Enceladus* were seen with ease near conjunction, and the planet and its ring presented a beautiful appearance; but a haze soon covered the sky.

The observation of *Enceladus* on Feb. 18, and of *Tethys* on Feb. 28, were made by A. Hall, jun.

The observations of the companion of *Sirius* were delayed until later than usual. This object was difficult and faint, except on April 19. Double weight has been given to the observation of this date.

1885, *April* 30.

Observations of the Companion of Sirius, made at the Dearborn Observatory, Chicago, U.S.A. By Prof. G. W. Hough.

(*Communicated by the Secretaries.*)

	Date.	P.	s
		°	"
	1885·091	32·8	8·01
	·140	33·8	7·72
	·162	34·2	7·93
	·189	33·2	8·01
	·206	33·3	8·00
	·217	30·9	8·00
	·222	32·5	8·07
	·241	32·3	7·89
	·252	32·3	8·05
	·255	32·2	7·94
Mean	1885·197	32·7	7·96

On Daylight Occultations of Aldebaran in 1885. By J. R. Hind, F.R.S.

The following are particulars of two occultations of *Aldebaran* occurring in the present year in daylight. The angles from north point are reckoned as in the *Nautical Almanac.*

1. *Occultation of July* 8-9.

	Disappearance.		Reappearance.	
	h m	°	h m	°
Greenwich	23 24·1	55	0 15·5	317
Edinburgh	23 12·2	70	0 12·8	302
Liverpool	23 16·5	62	0 12·8	311
Dublin	23 12·5	61	0 9·1	311

2. *Occultation of Sept. 28.*

	Disappearance.		Reappearance.	
	h m	°	h m	°
Greenwich	20 33·0	132	21 19·3	234
Edinburgh	20 30·6	147	21 7·2	221
Liverpool	20 30·4	137	21 14·6	230
Dublin	20 27·8	135	21 14·4	232

The above are Greenwich mean times at the respective observatories.

Elliptic Elements of Comet II. 1883 (*Ross*). By Robert Bryant, B.A.

Having seen published as yet no discussion of all the observations of this comet, the reduction of the same was undertaken, and the results below are communicated, as they may be not without interest to the Society.

The reason for no complete determination of the elements having been made is perhaps due to the scant material upon which to work, and to the fact that few as the observations are, they do not in general show that agreement with an ephemeris computed from approximate elements which they should do.

From the mean of two sets of approximate parabolic elements an ephemeris was computed, extending from a few days before the first observation of the comet to a few days after it ceased to be visible, and as this ephemeris was originally intended to form the basis of the subsequent determination of the elements, it was computed with the greatest care for alternate days in order to reduce the possibility of error in the interpolation. This was interpolated with fourth and sometimes fifth differences, and the results when corrected for parallax were compared with all the published observations of the comet. Many of the observations then showed far greater and irregular discordances than could be attributed to errors of computation.

On the suggestion, therefore, of Dr. Hind (to whom my thanks are due for the assistance rendered in this and in work of a kindred nature) it was resolved to obtain the elements from Tebbutt's observations alone, which presented almost uniform discordance when compared with the ephemeris.

To this end a parabola was computed passing through the places of his extreme observations, and comparison was made with a middle place. It was found that although an agreement might be forced between the extreme observations and one coordinate of the middle place, yet the remaining coordinate exhibited a large error. It was, therefore, determined to obtain elements with an eccentricity different from unity, and to pass to these by means of differential equations.

The first corrections to the approximate elements were of such magnitude as to scarcely justify the assumption that the squares and higher powers of the differentials might be neglected. Consequently, fresh coefficients were calculated and a redetermination of the differentials made, the results of which are given below.

The elements from which the ephemeris was computed in the first instance are

T	1883, Dec. $25^{d} \cdot 30154$ G.M.T.	
ω'	$113^{\circ}\ 36'\ 50''\cdot 5$	Mean Equator 1884·0
☊$'$	$254\ 33\ 46\cdot 1$	Mean Equator 1884·0
i'	$110\ 37\ 51\cdot 1$	Mean Equator 1884·0
log q	9·490993	

Comparison was made with the following three places observed by Tebbutt at Windsor, N.S.W.

Windsor M.T.		R.A.	Decl.
	d h m s	h m s	° ′ ″
1884, Jan.	19 9 37 42	22 54 35·62	−41 46 56·3
	19 9 37 42	22 54 35·53	−41 46 56·5
	25 9 14 35	23 22 33·60	−41 59 19·6
	25 9 14 35	23 22 33·79	−41 59 18·7
Feb.	2 9 38 9	23 48 47·64	−41 44 19·1

the mean of each double observation being taken.

The respective corrections to two sets of elements gave the following approximate elliptic elements :—

	I.		II.	
T ...	1883, Dec. $25^{d} \cdot 139019$ G.M.T.		1883, Dec. $25^{d} \cdot 137890$ G.M.T.	
ω' ...	$112^{\circ}\ 43'\ 47''\cdot 01$	Mean Equator 1884·0	$112^{\circ}\ 43'\ 34''\cdot 65$	Mean Equator 1884·0
☊$'$ ...	$254\ 29\ 51\cdot 25$	Mean Equator 1884·0	$254\ 30\ 35\cdot 61$	Mean Equator 1884·0
i' ...	$110\ 21\ 18\cdot 98$	Mean Equator 1884·0	$110\ 21\ 22\cdot 05$	Mean Equator 1884·0
log q ...	9·4885050		9·4886041	
e ...	0·9855308		0·9851042	

These give the following residuals for the three observations above (obs.-comp.).

I.	$d\alpha \cos \delta$	$+8''\cdot 53$	$+10''\cdot 51$	$+13''\cdot 39$
	$d\delta$	$-1\cdot 64$	$-1\cdot 65$	$-0\cdot 67$
II.	$d\alpha \cos \delta$	$+13\cdot 72$	$+14\cdot 88$	$+19\cdot 06$
	$d\delta$	$-0\cdot 35$	$-0\cdot 99$	$-1\cdot 72$

From the first of the above sets of elements a new set of differential coefficients was derived and the following equations

were obtained, the first and second independent terms in each equation referring respectively to the residuals in the three places derived from the first and second set of elements:—

$$8{\cdot}03449_n dT + 9{\cdot}70595 de + 9{\cdot}99668 d\log q + 9{\cdot}73417_n d\Lambda' + 9{\cdot}58974_n \sin i' d\Omega' + 7{\cdot}88138 di' = 1{\cdot}09528,\quad 1{\cdot}30202$$

dT	de	$d\log q$	$d\Lambda'$	$\sin i' d\Omega'$	di'	=	
$8{\cdot}22898$	$8{\cdot}61768_n$	$9{\cdot}92744$	$9{\cdot}58653_n$	$0{\cdot}00377_n$	$9{\cdot}68413$	$=0{\cdot}37953_n$,	$9{\cdot}70874_n$
$7{\cdot}74293$	$9{\cdot}77043$	$0{\cdot}04388$	$9{\cdot}82666_n$	$9{\cdot}59120_n$	$8{\cdot}81171_n$	$=1{\cdot}18531$,	$1{\cdot}33639$
$8{\cdot}11376$	$7{\cdot}75546_n$	$9{\cdot}91114$	$9{\cdot}60366_n$	$9{\cdot}97886_n$	$9{\cdot}75593$	$=0{\cdot}38120_n$,	$0{\cdot}15935_n$
$7{\cdot}28605_n$	$9{\cdot}82430$	$0{\cdot}05673$	$9{\cdot}88482_n$	$9{\cdot}59477_n$	$9{\cdot}17915_n$	$=1{\cdot}28810$,	$1{\cdot}44145$
$8{\cdot}00727$	$8{\cdot}49576$	$9{\cdot}89973$	$9{\cdot}63295_n$	$9{\cdot}94917_n$	$9{\cdot}80384$	$=9{\cdot}98727_n$	$0{\cdot}39675_n$

where $d\Lambda' = d\omega' - d\Omega'$.

The differentials of T, q, and e are expressed in parts of the radius as unity.

In these equations the addition and subtraction was performed by logarithms and checked by natural numbers.

Finally, all the unknowns were substituted in the last of the equations, the agreements between the true and computed values of the independent terms showing that the solution had been correctly performed.

The following are the values of the differentials:—

dT	$-0{\cdot}013386$,	$-0{\cdot}004733$
$d\log q$	$-0{\cdot}0002293$,	$-0{\cdot}0002422$
de	$-0{\cdot}0012183$,	$+0{\cdot}0000121$
$d\Lambda'$	$-287''{\cdot}49$,	$-67''{\cdot}07$
$d\Omega'$	$-\ \ 5{\cdot}45$,	$-59{\cdot}79$
di'	$-\ 87{\cdot}14$,	$-49{\cdot}73$

and thus the following elements are obtained:—

T	...	1883, Dec. $25^d{\cdot}125633$ G.M.T.	1883, Dec. $25^d{\cdot}133157$ G.M.T.
ω'	...	$112^\circ\ 38'\ 54''{\cdot}07$	$112^\circ\ 41'\ 27''{\cdot}79$
Ω'	...	$254\ 29\ 45{\cdot}80$	$254\ 29\ 35{\cdot}82$
i'	...	$110\ 19\ 51{\cdot}84$	$110\ 20\ 32{\cdot}32$
$\log q$	...	$9{\cdot}4882757$	$9{\cdot}4883619$
e	...	$0{\cdot}9843125$	$0{\cdot}9851163$
P	...	$86{\cdot}915$ sid. years	$94{\cdot}075$ sid. years

These elements do not exhibit *inter se* that agreement which

one might expect, considering that they are both derived from the same observations. They are presented, however, simply as the results of computation, and may serve to illustrate the difficulty of determining the orbit from the data.

The following residuals show how closely each set of elements represents the observed places (obs.-comp.) :—

I.	$d\alpha \cos \delta$	$+0''.86$	$+0''.11$	$+0''.07$
	$d\delta$	$+0.19$	$+0.08$	-0.81
II.	$d\alpha \cos \delta$	$+0.25$	$+0.07$	$+0.24$
	$d\delta$	-0.12	0.00	-0.07

An inspection of the observed places shows at once that these residuals are far within the errors of observation.

These elements referred to the ecliptic are

T	1883, Dec. $25^d.625633$ Univ. Time*		1883, Dec. $25^d.633157$ Univ. Time†	
ω	$137^\circ\ 37'\ 40''.49$	Mean Ecliptic 1884.0	$137^\circ\ 40'\ 21''.68$	Mean Ecliptic 1884.0
☊	264 12 29.31		264 12 38.65	
i	114 44 24.00		114 45 4.69	
$\log q$	9.4882757		9.4883619	
e	0.9843125		0.9851163	
P	86.915 sid. years		94.075 sid. years	

Throughout the whole computation checks and the method of differences have been employed wherever such were applicable; in default of these the calculation has always been performed in duplicate, and where possible by independent means. Although the agreement between observation and computation is satisfactory, and although the determination of the elements has been made with every possible care (from logarithms to seven places of decimals, and, where the variation was rapid, from eight places in order to get the seventh correct), yet it must be remembered that in addition to the difficulty of making the observations, the results are derived from only three places, that the extreme observations are separated by an interval of only 14 days, and that the included arc of anomaly is only 14°.

My thanks are also due to Professor Oppolzer, of Vienna, for his suggestions in connection with the work.

London: 1885, June.

* *i.e.* 1883, Dec. $25^d.125633$ G.M.T. in the ancient mode of reckoning.
† *i.e.* 1883, Dec. $25^d.133157$ " "

Reply to Mr. Stone's Paper on Screw Errors as affecting the N.P.D. of the Cape Catalogue for 1880. By David Gill, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope.

In the following paper it will be convenient to take up the points raised by Mr. Stone nearly in the order in which he has stated them.

A considerable portion of my paper, which originated the present discussion, was devoted to a proof that errors of considerable magnitude were produced by wear of the screws and not by constraint, as argued by Mr. Stone.

Mr. Stone appears now to have given up that theory, as he does not support it by any further argument; and whilst admitting that wear may take place, he denies that such wear is sufficient to lead to serious errors in the resulting N.P.D.'s.

Here it will be well to define what are to be considered "serious errors" in this discussion.

A Star Catalogue may be judged by various standards.

1st. Merely as a Zone Catalogue, in which the differences of N.P.D. from standard stars are pretty accurately observed, the adopted places of the standard stars being the reference points of each zone. Or,

2nd. The N.P.D.'s may be considered fundamental, that is proper, without the application of any corrections, for discussions of the law and constant of refraction, the determination of precession and the solar motion in space, and for refined investigations on proper motion.

In the former case an error of $0''\cdot5$, due to accidental screw error, cannot be considered "serious." But in the latter case, if even a much smaller error than $0''\cdot5$ is systematically applicable to the observations of a long successive period, then we must regard such error as "serious," because the Cape (1880) Catalogue having been observed in zones of 10° in Declination, all the results of large adjacent portions of the Catalogue will, in such case, be affected systematically by that common error.

From Mr. Stone's expression (p. 140) of the "hope that Mr. Gill will be better advised than to apply empirical corrections to the Cape (1880) Catalogue," it must be understood that Mr. Stone regards the N.P.D.'s of his Catalogue as fundamental, and consequently that criticism belonging to the latter of the two classes above indicated is legitimately applicable to them.

Passing over, for the moment, all questions as to the origin of the screw errors, and appealing directly to facts, as Mr. Stone desires, the matter in discussion is fortunately reduced to a very simple one by the admission of Mr. Stone that "the curve which Mr. Gill has given (representing the errors of the screws) is the

reproduction of one which I (Mr. Stone) constructed from these observations in 1877."

I have never seen the curve to which Mr. Stone refers; but it is at least satisfactory to find that, from the same observations, we have arrived precisely at the same curve.

That curve gives the figures in Table V., p. 86, of my original paper, and we have therefore only to deal with precise figures about the accuracy of which there is no question.

Any given observation made about the epoch 1877 can thus be rigorously corrected for screw error from the data of Table V., provided that we know the original readings of the screws.

1st. In the observation of the star.
2nd. In determining the runs.
3rd. In the Nadir determination.

Unless, therefore, Mr. Stone can point to some error in the method of computation employed (described at p. 87) he must admit the accuracy of my Tables VII. and VIII.

As Mr. Stone instructed his assistants not to make observations below $5^{r}\cdot0$ (Mr. Stone's negative readings), it will be assumed in the following discussion that no such readings have been made, although, as a matter of fact, not a few of such exist. But apart from these readings we must suppose that the other readings fall with equal frequency on any part of the screw from $5^{r}\cdot0$ to $10^{r}\cdot0$, for it is impossible to restrict the supposed range within narrower limits.

Thus, if

r_0 is the accidental mean error of observation,

r_s is the error due to the screw.

Then the mean error of the Catalogue place of any star is

$$r_0 = \sqrt{\frac{r_0^2}{n} + r_s^2}$$

where n is the number of observations.

This expression would not be true if the star was observed over a considerable range of the Declination micrometer screw, because in that case different readings of the Circle microscopes would have been employed in each observation, and thus there might have been a tendency to eliminate to some extent the errors of these microscopes. But it was the practice of the observers to set the micrometer screw, for periods of many months together, always at or very near the same reading (within a very few seconds of arc), and to place the horizontal wire on the image of the star as it entered the field before clamping in N.P.D. The reason was doubtless to render the observations as nearly as possible independent of the adopted value of the Declination micrometer screw, but it has the effect of bringing the whole errors of the screws at the particular reading into the mean Catalogue place of the star.

If the reading for a particular star fell between $6^{r}\cdot0$ and $9^{r}\cdot3$ the error due to the Circle micrometer screws (apart from the systematic error of run and Nadir point) never exceeds $\pm0''\cdot1$, *but one-third of the observations must of necessity fall above or below these limits, when the accidental error so introduced ranges from* $0''\cdot1$ *to* $0''\cdot95$. It is surely important to correct such errors, when one has access to the original observations, if a refined investigation of the proper motion of a particular star is being made.

Much as such errors are to be regretted in the original results, they do not affect the Catalogue systematically.

That is to say, if, for example, we compare a number of stars as observed in Europe and at the Cape, for discussion of the law and constants of refraction, such accidental errors, due to the Circle screws, might be supposed to be practically eliminated in the mean of a large number of stars.

But the practice of observing the Nadir for long periods at the same reading of the Declination micrometer, coupled with the errors of the screws, has led to systematic errors extending over large contiguous portions of the Catalogue.

From January 1871, when the work of the Catalogue was commenced, till 1872, May 13, the whole of the Nadir readings (except a few negative readings) are made between $5^{r}\cdot0$ and $5^{r}\cdot5$, for the lower reading of the Circle microscopes, the mean reading, as well as the great majority of the readings being at $5^{r}\cdot3$. During that period the practice followed by all the observers was to set the telescope-micrometer to $10^{r}\cdot0$, and then to clamp in N.P.D., when the direct and reflex images of the horizontal wire were nearly in coincidence. On 1872, May 13, a change suddenly occurs in the Nadir reading, produced by a change in the drum, by which the number of whole revolutions is read off. That is to say, on 1872, May 13, the same nominal reading of the counter drum corresponds with a portion of the screw differing by two revolutions from that which it formerly did. This change seems to have been produced by accident.

The counter drum is driven by an endless screw acting on a toothed edge cut in the drum, the axis of the endless screw terminating in a pinion which is acted on by a bevel wheel attached to the head of the Declination micrometer screw. By long use the screw and fine teeth became worn, so that a slight accidental pressure on the counter-head was sufficient to cause it to slip. The "arbitrary changes" recorded in the published Tables of Nadir appear to be entirely due to the accidental slipping of the counter drum, and the observers have persevered in the same nominal settings of the Declination micrometer. On 1874, November 10, the fine teeth had become so worn at the point corresponding with 10^{r} that the counting drum was shifted forty divisions forward, so that the screw might work in teeth that were less worn. From this date till the end of 1879 the observers systematically observed the Nadir at 50^{r}, but there

are frequent cases of slipping of the counter (or arbitrary changes of a number of whole revolutions). These are all recorded in the following Table IX. Thus the "arbitrary changes" define a series of epochs, through each of which the Nadir readings were made systematically at nearly the same readings, and all systematically differing from the Nadir readings of the adjoining epochs.

To complete our knowledge of the systematic errors of the N.P.D.'s in each of these epochs (as distinguished from the accidental errors already described) we have only to ascertain the part of the screw at which the determinations of run were made. In observing the run an undeviating routine has been followed, and the great mass of the observations have been made with the lower reading about $5^r{\cdot}2$ to $5^r{\cdot}4$. The general distribution may be judged of from the Table for 1872–3, at p. 81, though after that the range is still more restricted.

In Table IX. the mean lower reading of the run is given for each of the epochs.

TABLE IX.

1 Rotation Number.	2 Limiting Dates of Epoch.	3 Mean Nadir Reading.	4 Lower Reading for Runs	5 Range of Errors.	6 Mean Error.	7 Systematic Error.
		r	r	″ ″	″	″
I.	1871, Jan. 1 1872, May 12	5·3	5·3	−0·59 to +0·41	±0·31	+0·24
II.	1872, May 13 1873, May 28	6·2	5·3	−0·90 to +0·10	±0·20	−0·07
III.	1873, May 29 1875, Jan. 31	6·7	5·3	−0·95 to +0·05	±0·22	−0·12
IV.	1875, Feb. 1 1875, Feb. 15	9·1	5·3	−0·81 to +0·19	±0·19	+0·02
V.	1875, Feb. 16 1875, Mar. 10	6·4	5·3	−0·92 to +0·08	±0·20	−0·09
VI.	1875, Mar. 11 1875, Apr. 4	6·9	5·3	−0·96 to +0·04	±0·22	−0·13
VII.	1875, Apr. 5 1875, May 10	7·4	5·3	−0·98 to +0·02	±0·24	−0·15
VIII.	1875, May 11 1875, May 12	9·5	5·3	−0·75 to +0·25	±0·21	+0·08
IX.	1875, May 13 1875, July 20	7·0	5·3	−0·97 to +0·03	±0·23	−0·14
X.	1875, July 21 1876, Feb. 20	7·6	5·3	−0·99 to +0·01	±0·24	−0·16
XI.	1876, Feb. 3 1876, Mar. 22	8·6	5·3	−0·90 to +0·10	±0·20	−0·07

1 Rotation Number.	2 Limiting Dates of Epoch.	3 Mean Nadir Reading.	4 Lower Reading for Runs.	5 Range of Errors.	6 Mean Error.	7 Systematic Error.
		r	r	" "	"	"
XII.	1876, Mar. 23 — 1876, Oct. 13	6·7	5·3	−0·95 to +0·05	±0·22	−0·12
XIII.*	1876, Oct. 16 — 1878, Dec. 31	7·2	5·3	−0·99 to +0·01	±0·24	−0·16

In the preceding Table

Column 1 is a rotation number adopted for convenience of reference.

" 2 gives the range of date in the epoch during which the Nadir readings were made at practically the same parts of the microscope screws, for reasons above stated.

" 3 gives the mean Nadir readings during the corresponding epoch.

" 4 gives the mean lower reading for runs.

" 5 gives the range of error when computed for each $\frac{1}{10}$ of a revolution from $5^{r}\cdot0$ to $10^{r}\cdot0$ from Table V., p. 86, by the method and formulæ on page 87, with the arguments N from Column 3, and R from Column 4 of Table IX.

" 6 gives the *mean error* (or the square root of the mean of the squares of the errors) computed for each $\frac{1}{10}$ of a revolution from $5^{r}\cdot0$ to $10^{r}\cdot0$.

" 7 gives the systematic error of the zone, computed on the assumption that the readings fall as often at $5^{r}\cdot0$ as at 5·1, as at 5·2, &c. . . . $10^{r}\cdot0$—in other words, the algebraic mean of the errors computed for each $\frac{1}{10}$ of a revolution.

The most important facts to be deduced from this Table are :

First. That whilst the wear of the screws produces accidental errors which range from $-0''\cdot99$ to $+0''\cdot41$ (see Column 5), the *mean error* of any N.P.D. taken by chance (as in the comparison of two Catalogues) ranges from $\pm0''\cdot19$ to $\pm0''\cdot31$ (see Column 6).

Second. That excepting the two brief epochs IV. and VIII. there is a *systematic difference* of nearly $0''\cdot4$ between the N.P.D. for Epoch I. and the rest of the Catalogue.

Mr. Stone appeals to a comparison between the N.P.D.'s of

* Except on 1876, Oct. 20, when the counter was displaced one revolution, and readjusted before the work of next night. The counter seems to have had a frequent tendency to slip, but during Epoch XIII. it seems to have been always carefully replaced to the same reading for the same revolution of the screw.

the Cape 1860 and 1880 Catalogues as a proof of the freedom of the latter from errors due to wear of the screws. His selection of the stars rests on a very clear and intelligible basis, and his appeal to such evidence seems at first sight a perfectly fair one.

But it is necessary in discussing so nice a question to take the most minute precautions in arriving at the preliminary data, and here it does not appear that Mr. Stone has stated in sufficient detail the facts which have led to the assumption on which his argument is based.

Mr. Stone quotes "the three independent sources of error" which enter into the discordances, besides the hypothetical errors which may be due to errors of the screws.

These are in his own words the following:—

(1) There will be the error of the N.P.D. given in the Cape Catalogue 1860; I shall certainly not over-estimate the probable error due to this cause by taking

$$e_{1860} = 0''\cdot 1.$$

(2) There will be the combined effects of error in the precession constant, and adopted proper motion for 20 years. As this cannot be less than $0''\cdot 1$, and will be about one-sixth of that due to the relative errors of Bradley's N.P.D. and the recent Greenwich observations, I cannot over-estimate the probable error by taking

$$e_{\mu} = 0''\cdot 2.$$

(3) There will be the probable error of the N.P.D. of the Cape Catalogue of 1880. As there are generally only three or four observations employed in fixing the N.P.D., the probable error, independently of any possible error due to screw wear, will be about

$$e_{1880} = 0''\cdot 25.$$

Now, as our object is to determine the existence or amount of a small hypothetical error from discordances which include three other independent sources of error, it is obvious that very small errors in our estimates of each of the three independent sources of error may entirely vitiate the result. I propose therefore to re-examine Mr. Stone's assumptions, as he has not stated the grounds on which they have been arrived at.

It must be remembered that the two Catalogues in question rest on observations made with the same instrument, in the same situation, with the same division errors, the same thermometers similarly exposed, and reduced with the same refraction tables. Therefore coincidence in the results is no more proof of absolute accuracy than any similar continuous series of observations with the same instrument in the same year. We may therefore obtain data to arrive at a sufficiently exact estimate of errors (1) and (3) from the accordance *inter se* of the results of N.P.D. for one or more stars observed in a single year. I have therefore selected twelve stars which have been the most frequently observed both in 1856 and 1860, and have deduced the *mean error* of a single observation in N.P.D., and find it to be

$$r_{1860} = \pm 0''\cdot 7144.$$

For the 1880 Catalogue I have selected a number of frequently observed stars from the published ledgers, and deduced the mean error of a single observation

$$r_{1880} = \pm 0''.6214,$$

and these mean errors do not differ very materially from the probable errors of Mr. Stone's sources of discordance (1) and (3).*

But I am quite at a loss to understand the meaning of Mr. Stone's statement (above quoted) relative to his source of error (2). Does Mr. Stone imply that the probable error of the annual variation of stars, such as he has selected (which have been observed by Bradley, Piazzi, and at every observatory in the world since), amounts to $\pm 0''.01$ (*i.e.* $\frac{1}{20}$ of $0''.2$), and that of all these observations the only reliable data for determining the annual variation are the observations of Bradley and the modern Greenwich observations? I do not think that either one or other of these opinions will receive the support of astronomers.

It fortunately becomes unnecessary to discuss these points here by simply referring Mr. Stone to Professor Lewis Boss's work on the Declination of the fixed stars; where, in the final Catalogue, there is a column which gives for each star the "probable error of annual variation," not as *adopted* by Professor Boss, but as rigorously deduced by him from the data at disposal.

Of Mr. Stone's 93 stars, 53 occur in Professor Boss's Catalogue, and the mean of the probable errors for the annual variations of these 53 stars is $\pm 0''.0031$, so that Mr. Stone's estimate appears to be fully three times too great.

The *mean error* corresponding to a probable error of $\pm 0''.0031$ is $\pm 0''.00458$, which for twenty years corresponds with

$$r_m = \pm 0''.091,$$

where r_m is the *mean error* of the annual variation in twenty years.

To find, from the discordances between the 1860 and 1880 Catalogues, the mean error of a star's place due to errors of the screw, we have then the following equation from each of Mr. Stone's stars:—

$$(1860 \text{ Cat.} - 1880 \text{ Cat.})^2 = \frac{r^2_{1860}}{n_{1860}} + \frac{r^2_{1880}}{n_{1880}} + r^2_m + y^2,$$

where r_{1860}, r_{1880}, r_m have the values already found, and where the mean value of y will be found from the mean of the equations.

* The probable errors (1) and (3) become for the mean number of observations (33 and 34 respectively), $\pm 0''.083$ and $\pm 0''.21$, instead of $\pm 0''.1$ and $\pm 0''.25$, as adopted by Mr. Stone.

This value of y should agree precisely with that of Column 6 of Table IX. (viz. about $\pm 0''.23$) provided—

(α) That the Circle screws were absolutely perfect during the period 1855–60.

(β) That each star of Mr. Stone's list was observed throughout the whole of the observations upon which its place in the 1880 Catalogue depends, with the same readings of the micrometer screw. (If this is not assumed, then in each equation we must write $\frac{y^2}{n_{1880}}$ for y^2).

Now, as a matter of fact, neither of these two conditions is fulfilled. It has already been shown, in my original paper, that during a similar period the screws, which were new and practically errorless in 1880, had acquired decidedly serious errors by wear in 1884. It is, therefore, reasonable to argue that similar screws of similar material and made by the same makers would also acquire similar errors from constant use between 1855 and 1860. The partial wear of the screws in the period 1855–56 would therefore tend to diminish the discordance between the 1860 and 1880 Catalogue, and hence also the value of y.

The second condition is not fulfilled because the stars selected for this comparison by Mr. Stone (for other and sufficient reasons) are not zone stars, but clock stars, the Declinations of which have been observed for the 1880 Catalogue at miscellaneous epochs (epoch being here understood in the sense of Table IX.), and consequently in many cases the same star has been observed with different Nadir points and different readings of the micrometer screw. In this way the effect of errors of the screws is to some extent eliminated, and hence the resulting value of y will be diminished.

Thus, because the conditions (α) and (β) are not *fulfilled*, the *mean* value of y, computed from the discordances of the two Catalogues, should not amount to the full theoretical amount of Table IX. Column 6—that is, it should be less than $\pm 0''.23$.

We find accordingly from the sum of the equations—

$$93\,y^2 = 3.0051,$$

and thence

$$y = \pm 0''.18.$$

Thus the very stars which Mr. Stone has chosen, when fairly and properly discussed, prove the existence of errors which correspond in effect with those deduced in my original paper from quite different data.

Mr. Stone contends that if x (the portion of the *probable error* in a star's place which is due to errors of the screws) did not amount to $\pm 0''.5$ (in other words, if y in the present dis-

cussion did not amount to $\pm 0''.74$), then my paper should not have been written.

I am sorry that Mr Stone thinks so.

When it is remembered that, from the form of the curve of error which such a screw acquires from the process of wear, nearly two-thirds of the part of the screw in use must have very small errors, the errors of the remaining one-third of the screw must be very large to produce a computed *mean* error for the whole screw of $\pm 0''.74$. Some of the absolute errors would in that case amount to nearly $3''$.

Does Mr. Stone contend that all errors under such an amount should be passed without notice or mention? I do not think so; and I feel sure that when Mr. Stone further considers the matter he will not think so.

I hold rather that in fundamental observations we have such numerous sources of error which almost elude our search, that we cannot afford to dispense with the rigid correction of any error that is capable of being so easily and certainly determined as the errors of the screws. It is because I have felt this, and because, in special cases, it will be useful to apply corrections for these screw errors to the 1880 Catalogue, and because it was important that further proof should be given to astronomers of the necessity for rigid determination of the errors of the microscope screws from time to time, that my original paper was written. These are surely sufficient reasons even if the resulting errors had been much smaller than they have proved to be.

But Mr. Stone contends that the corrections which were applicable in 1877 would not be applicable at another time, not because the wear of the screws might be sensibly different in 1871 and 1877, but "from changes in the adjustment of the index from which the revolutions are taken."

It is, however, easy to show that no such changes occurred in the Cape Circle till 1879. The "drums," by which the fractions of a revolution are read, are not attached by mere friction to the screws as in some transit circles, but are squared on, there being a square hole in the drum-head fitting a slightly tapering square on the end of the axis of the screw; and the fit is so nice that the drum will only go home when one marked face of the tapered square is placed against one marked surface of the square in the drum. Thus no change of a fraction of a revolution in the readings can be made.

The bearings of the screws also are immovable, being hollow cones bored in projections cast in one flow with the gun-metal ring to which all the microscopes are attached.

The only way, therefore, in which a real change of a whole revolution in any particular microscope could be made would be by changing the comb one revolution; and to restore the similarity of the numerical readings of the six microscopes, the object-glass of the microscope in question would have to be shifted in a plane at right angles to the microscope axis in a direction parallel to

the screw. The microscopes have no tubes in the ordinary sense, the mounting of each objective being attached to a piece of brass, which is bolted to the face of the pier, the tubes being simply holes in the pier.

The only means of giving side adjustment to the object-glass is by widening the holes in the flanges, through which the screws pass, by which the objective mountings are screwed to the piece of brass in question.

I do not think that the holes in the flanges of any of the object-glasses are sufficiently widened to allow so large a shift as $\pm 1^r$; and besides, we have it on the authority of Mr. Stone (Introduction to Cape Observations, 1875, p. xi.) that "the effective range of the screws in the Cape microscopes does not extend, at most, over more than six revolutions;" therefore, such a change as one revolution could not be made.

The changes that may have been made from time to time in the relative position of the object-glasses have thus been limited to quantities corresponding with a fraction of a revolution, and as the object of any such changes should have been (and in Mr. Stone's experienced hands would certainly have been) merely to render the readings of the microscopes as nearly the same as possible, there would have been no object in attempting to make larger changes. Such small changes can readily be allowed for by taking for argument in the table of screw corrections not the reading of microscope A only, but the mean of the readings of the six microscopes, and this has been done throughout the present discussion.

Mr. Stone (Introduction to Cape Observations, 1875, p. xi.) quotes observations of the Nadir on 1875, November 22, by three observers, of which the means are the following:—

Reading of A.

	0^r	$2^r \cdot 0$
Nadir	180° 7′ 26″·62	26″·29,

and he adds, "it appears from observations made in the present year (1877), and carried systematically over the whole range of the screws, that the difference above indicated is real, but is about as large as the greatest difference obtained throughout the range of the screws employed in the observations."

Why does Mr. Stone not quote those observations of 1877 which prove the reality of the above difference, and which also appear to me to prove differences from two to three times as great (see Table V.), even when negative readings are excluded? Indeed, the above observations seemed to me at first to prove that from the comparatively small discordance (0″·33) between the Nadirs of 0^r and $2^r \cdot 0$ the screw errors really were different and smaller in 1875 than in 1877. According to our Table V., if the readings were made at 0^r and $2^r \cdot 0$ (*i.e.* at $5^r \cdot 0 + 7^r \cdot 0$) the screw errors should have produced a difference of about 1″ in the two Nadirs.

But on turning to the original observations I find that the readings of micrometer A were not 0^r and $2^r{\cdot}0$, but $0^r{\cdot}7$ and $2^r{\cdot}7$, the mean of the six microscopes being $0^r{\cdot}56$ and $2^r{\cdot}56$. The lower reading of microscope A for the run was also $0^r{\cdot}7$, or for the mean of the six microscopes, $0^r{\cdot}56$.

With these means as arguments we can correct the Nadir by our Tables V. and VI.; the corrections are respectively $-0''{\cdot}20$ and $+0''{\cdot}21$, so that the corrected Nadirs become

Microscope Reading.

	$0^r{\cdot}56$	$2^r{\cdot}56$
Nadir	$180°\ 7'\ 26''{\cdot}42$	$26''{\cdot}50$,

an agreement which is sufficiently precise.

But it may be fairly argued that during the period 1871–77 a very large number of observations was made, and therefore the screw errors would change considerably by wear between these dates. There is no doubt that this must be so, but probably not to the extent that may at first be supposed.

From a discussion of the runs observed at different times, and over different parts of the screw, during the period 1880–1884 (the details of which will be published in the Cape Observations), I find that the wear does not change proportionally with the number of observations, but is expressed for an epoch between 1880 and 1885 by ak, where k is the error of the screw produced by wear after N observations (N being actually about 17,000 when the screw errors were determined in 1884), and

$$a = 1{\cdot}57\,\frac{n}{\mathrm{N}} - 0{\cdot}57\left(\frac{n}{\mathrm{N}}\right)^2.$$

where n is the number of observations made since 1880 at the epoch for which the error is required.

That is to say, the wear is much more rapid at first than afterwards; for if the expression were true the wear would cease in eight years, and afterwards diminish! The formula is of course merely used as a sufficiently approximate form of interpolation.

We may also arrive at a like conclusion by other facts.

The second set of screws, mounted in 1880, are of the same material and made by the same artists as the first set. We may probably conclude, therefore, that the law of wear of both sets would be nearly alike.

The curve of errors of the new screws (as determined by careful measurement with the apparatus described and figured at pp. 64–65) is given in the following diagram (fig. 8); these errors result from four years' wear, and are indicated by a continuous curve.

The curve of the errors of the old screws, resulting from twenty-one years' wear, is indicated by a dotted curve in the same diagram.

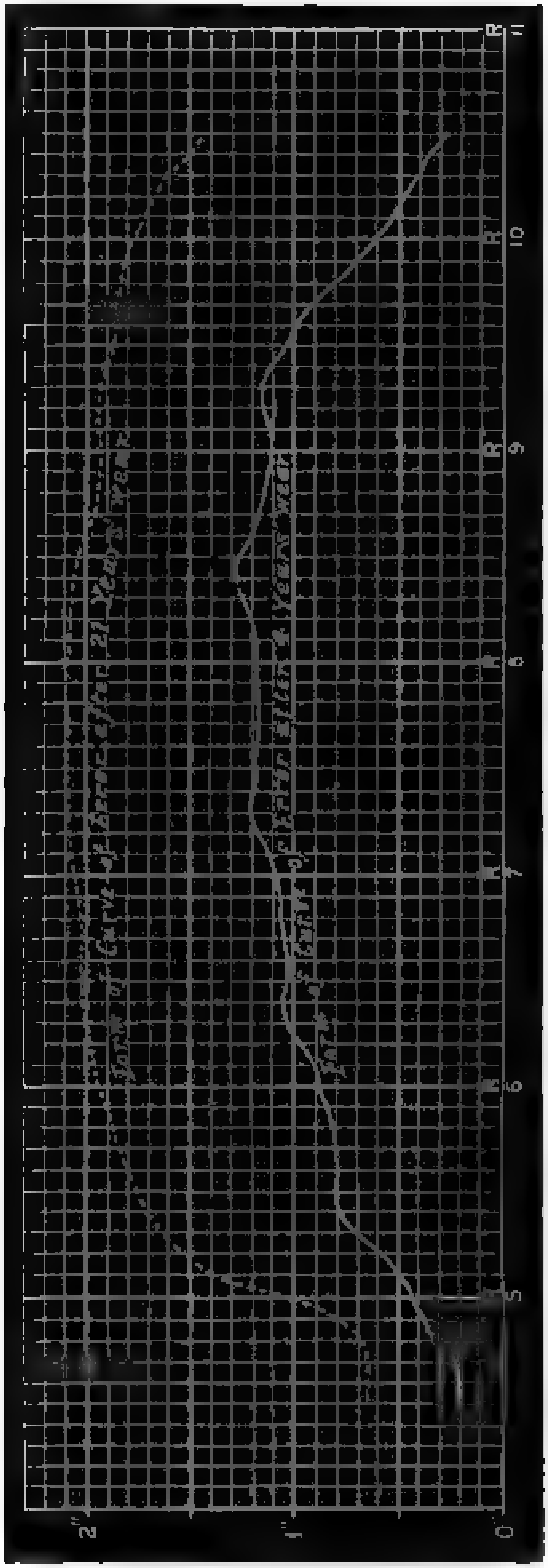


Fig. 8.—Curves showing errors of screws after twenty-one, and four years' wear.

It becomes obvious that the wear has been much less rapid during the last seventeen years than in the first four years of the screw's work, else the two curves would differ much more widely. This is probably because the deeply-cut male and female threads do not at first bear along the whole of the faces, but gradually, by mutual wear, attain to more complete contact of their bearing surfaces.

The discussion of a comparison between Right Ascensions of the Cape Catalogues for 1850 and 1880 appears to be somewhat irrelevant to a paper on screw wear; I therefore defer reply to Mr. Stone's remarks on this subject till a more fitting opportunity.

The Velocity of Meteors. By W. F. Denning.

At the December meeting of the Royal Astronomical Society, and again at the May meeting, certain remarks were made as to the velocity of meteors and the enormous speed necessary to explain the occurrence of fixed, long-enduring radiant points. I wish to say that no such velocities are observed, and that it is impossible the fixed radiants can be explained by this means. I quite agree with the remarks that emanated from Col. Tupman as to the difficulty of accounting for these long-continued showers, and also that the very great velocities indicated by Mr. Proctor have never been recognised. The meteors falling from the stationary radiants, referred to in my paper read at the December meeting, appear to be of ordinary character, and their motions cannot differ essentially from the parabolic velocities exhibited by the planetary streams.

Mr. Ranyard, at the May meeting, asked for information as to whether the speed from any of the assumed fixed radiants had been determined from multiple observations of bolides and large meteors. The velocity has certainly been computed in several instances, and they accord with that of the usual planetary meteors. Of course, there is rather a wide limit of error in estimating the exact durations of flight, the intervals being so transient in most cases; but it is impossible that the meteors can travel at a rate anything approaching that suggested as the only explanation of the long enduring showers.

Let us take the instance of the display from near ϵ *Persei* at $61^\circ\!\cdot\!8+36^\circ\!\cdot\!8$, No. IV. of my list in the *Monthly Notices* for Dec. 1884, p. 101, which I regard as one of the very best cases of stationary radiation. A shooting star of about the 3rd mag. was doubly observed from this shower, at York and Oxford, at $11^h\ 28\frac{1}{2}^m$ on Aug. 10, 1872. The estimated duration was 0·5 second, and the actual length of the path traversed in the atmosphere was 20·4 miles, so that the resulting velocity was about forty-one miles per second. The radiant point was at

61°+39° (B.A. Report on Luminous Meteors for 1874, p. 281). A great fireball from the same stream was observed at Bristol and many other parts of England on Nov. 6, 1869, at 6^h 50^m. Prof. Herschel discussed a considerable number of observations, and found the radiant point at 62°+37°. The meteor had a real path of about 175 miles traversed in about five seconds, the velocity being some 35 miles per second, and somewhat greater than that of a body moving in a parabola. I observed the end of this fireball, and believe the duration to be much over-estimated; still, though the motion may have been hyperbolic, it could not have attained a figure anything like the terrific velocities which Mr. Proctor's hypothetical streams must follow.

That this fireball really belonged to the shower near *ε Persei* is rendered conclusive by the fact that on Nov. 3 and 4, 1877, I observed an active display of ordinary swift meteors from the point 61°+35°. I also saw a radiant at nearly the same place on Sept. 7–16 and Nov. 27–Dec. 6, 1877, and the following are the mean relative velocities and length of path as I registered them at the three epochs:—

	Mean Duration.	Mean Length.	No. of Meteors.
	sec.	°	
1877, Sept. 7–16	·23	9·15	10
Nov. 3-4	·30	13·30	10
Nov. 27–Dec. 6	·46	7·30	5

The motions evidently decrease with increase of time as the radiant recedes from the Earth's apex, and this seems a general feature.

Whatever may be the true explanation of the fixed radiants, it is not that which applies to the meteors a velocity many times greater than that of the planetary streams.

Bristol:
1885, *June* 1.

Ephemerides of the Satellites of Saturn, 1885–86.
By A. Marth.

The five inner satellites deviate so little from the plane of the ring that their deviations are most suitably treated as latitudes above this plane, the ascending node N and inclination I of which in reference to the plane of the Earth's equator are here assumed to be

for 1886·0 N = 126°·5510 I = 7°·0016.

The assumed longitudes of the five satellites in their orbits (*i.e.* their longitudes from the ascending node added to the right ascension N of the ascending node reckoned from the point of

the true equinox), referred to the time when the light arrives at the distance [0·950], are the following:

0^h Gr.	Mimas.	Enceladus.	Tethys.	Dione.	Rhea.
	°	°	°	°	°
1885, Sept. 15	63·253	314·793	305·911	93·924	276·687
Oct. 15	3·010	276·749	266·855	79·975	147·391
Nov. 14	302·768	238·705	227·799	66·027	18·095
Dec. 14	242·528	200·662	188·744	52·079	248·800
1886, Jan. 13	182·289	162·619	149·688	38·131	119·505
Feb. 12	122·050	124·576	110·633	24·183	350·209
Mar. 14	61·812	86·532	71·577	10·234	220·913
Apr. 13	1·576	48·488	32·521	356·285	91·617

The adopted daily sidereal motions of the five satellites and the corresponding periods of their sidereal revolutions are:—

		d	h	m	s
Mimas	° 381·99187	0	22	37	5·82
Enceladus ...	262·73186	1	8	53	6·86
Tethys	190·69812	1	21	18	25·96
Dione	131·53503	2	17	41	9·33
Rhea	79·69012	4	12	25	11·87

The values for *Mimas* belong to Sept. 15, 1885, and depend on the hypothesis of accelerated motion.

In the following tables P denotes the position-angle of the minor axis of the ring, L+180° the planetocentric longitude of the Earth referred to the plane of the ring, Λ+180° that of the Sun, or Λ−L the difference between the two. The apparent equatorial diameter of the ball and the diameter of the outer rim of the ring depend still on Bessel's determinations. The assumed proportion of the polar axis of the ball to the equatorial diameter is 0·900.

In the tables for the satellites a and b are the semi-axes of the apparent orbits, $l-$L the longitudes of the satellites in their orbits reckoned from the points which are in superior conjunction with the planet's centre or in opposition to the Earth in longitude. By adding to $l-$L the value of L from the first table, the longitudes l are found.

The values of P, a, b, and $l-$L are to be interpolated for the times for which the apparent positions of the satellites are required, and the rectangular coordinates x and y, reckoned parallel to the axes of the ring and expressed in seconds of arc, or, if polar coordinates are wanted, the position-angles p and distances s of the satellites in reference to the centre of the planet are then found by means of the equations

$$s \sin (p-\mathrm{P}) = x = a \sin (l-\mathrm{L})$$
$$s \cos (p-\mathrm{P}) = y = b \cos (l-\mathrm{L}).$$

0h Gr.	P	L	Latitude of Earth above plane of ring.	Latitude of Sun above plane of ring.	A−L
1885. Sept. 15	353°·188	100°·655	−25°·571	−26°·455	−6°·817
20	·171	100·969	·521	·440	6·922
25	·156	101·238	·477	·425	6·983
30	·144	101·461	·440	·410	6·998
Oct. 5	353·135	101·636	−25·410	−26·394	−6·966
10	·128	101·762	·388	·378	6·884
15	·124	101·838	·375	·361	6·752
20	·123	101·864	·370	·344	6·570
25	·124	101·839	·374	·327	6·338
30	·128	101·764	·387	·310	6·055
Nov. 4	353·135	101·639	−25·409	−26·292	−5·722
9	·145	101·465	·439	·274	5·340
14	·157	101·244	·476	·256	4·912
19	·171	100·980	·521	·238	4·440
24	·188	100·675	·573	·219	3·928
29	·207	100·333	·631	·200	3·378
Dec. 4	353·228	99·958	−25·693	−26·181	−2·796
9	·251	99·555	·759	·161	2·186
14	·276	99·131	·828	·141	1·555
19	·302	98·691	·899	·121	0·908
24	·329	98·242	−25·972	·100	−0·252
29	·356	97·789	−26·043	·079	+0·408
1886. Jan. 3	353·384	97·340	−26·113	−26·058	+1·064
8	·412	96·901	·182	·036	1·710
13	·439	96·478	·248	−26·014	2·340
18	·465	96·078	·310	−25·992	2·946
23	·489	95·707	·368	·970	3·523
28	·511	95·370	·421	·947	4·067
Feb. 2	353·531	95·070	−26·470	−25·924	+4·573
7	·549	94·812	·514	·901	5·037
12	·563	94·600	·552	·878	5·455
17	·574	94·437	·585	·854	5·825
22	·581	94·323	·612	·830	6·145
27	·585	94·260	·633	·806	6·414
Mar. 4	353·585	94·248	−26·649	−25·781	+6·631
9	·581	94·289	·659	·756	6·795
14	·574	94·382	·663	·731	6·907
19	·564	94·526	·661	·705	6·968

0h Gr.	P	L	Latitude of Earth above plane of ring.	Latitude of Sun above plane of ring.	A−L
1886.	°	°	°	°	°
Mar. 24	353·550	94·720	−26·653	−25·679	+6·980
29	·533	94·962	·639	·653	6·943
Apr. 3	353·512	95·251	−26·618	−25·627	+6·860
8	·489	95·585	·592	·600	6·732
13	·463	95·960	·559	·573	6·561
18	·435	96·375	·519	·546	6·350
23	·405	96·827	·473	·518	6·103
28	·373	97·314	·421	·490	5·821
May 3	353·338	97·834	−26·363	−25·462	+5·505

0h Gr.		Diameter of Ball. Equat.	Phase prec. l.	Polar	Axis of Ring. Major	Minor	Mimas. a_1	b_1	$l_1 - L$	Diff.
1885.		″	″	″	″	″	″	″	°	°
Sept.	15	17·64	0·062	16·22	40·66	17·55	27·74	−11·97	321·91	1909·82
	20	17·80	·065	16·36	41·02	17·67	27·98	12·06	71·73	·87
	25	17·96	·067	16·51	41·39	17·81	28·24	12·15	181·60	·92
	30	18·12	·067	16·66	41·77	17·94	28·50	12·24	291·52	1909·97
Oct.	5	18·29	·067	16·81	42·16	18·09	28·76	−12·34	41·49	1910·01
	10	18·46	·066	16·97	42·55	18·25	29·03	12·45	151·50	·06
	15	18·63	·065	17·13	42·95	18·41	29·30	12·56	261·56	·11
	20	18·80	·062	17·28	43·34	18·57	29·57	12·67	11·67	·16
	25	18·97	·058	17·44	43·73	18·74	29·83	12·78	121·83	·20
	30	19·14	·053	17·59	44·11	18·91	30·09	12·90	232·03	·23
Nov.	4	19·30	·048	17·74	44·48	19·09	30·34	−13·02	342·26	1910·28
	9	19·45	·042	17·88	44·83	19·26	30·58	13·14	92·54	·32
	14	19·59	·036	18·01	45·17	19·43	30·81	13·25	202·86	·35
	19	19·73	·029	18·14	45·47	19·59	31·02	13·36	313·21	·37
	24	19·85	·023	18·25	45·75	19·75	31·21	13·47	63·58	·40
	29	19·95	·017	18·35	46·00	19·90	31·38	13·57	173·98	·42
Dec.	4	20·05	·012	18·43	46·21	20·03	31·52	−13·67	284·40	1910·43
	9	20·12	·008	18·50	46·38	20·16	31·64	13·75	34·83	·43
	14	20·18	·004	18·56	46·51	20·26	31·73	13·82	145·26	·43
	19	20·21	·001	18·59	46·60	20·35	31·78	13·88	255·69	·43
	24	20·23	foll.	18·62	46·64	20·42	31·81	13·93	6·12	·41
	29	20·23	limb.	18·61	46·63	20·47	31·81	13·96	116·53	·39
1886. Jan.	3	20·21	0·002	18·59	46·58	20·50	31·77	−13·98	226·92	1910·36
	8	20·16	·004	18·56	46·48	20·51	31·71	13·99	337·28	·33
	13	20·10	·008	18·50	46·34	20·49	31·61	13·98	87·61	·29

		Diameter of Ball. Equat.	Phase prec. l.	Polar	Axis of Ring. Major	Minor	*Mimas.* a_1	b_1	l_1-L	Diff.
1886.		″	″	″	″	″	″	″	°	°
Jan.	18	20·02	0·013	18·43	46·16	20·46	31·48	−13·96	197·90	1910·24
	23	19·93	·019	18·34	45·94	20·40	31·33	13·92	308·14	·20
	28	19·82	·025	18·24	45·68	20·33	31·16	13·86	58·34	·15
Feb.	2	19·69	·031	18·13	45·39	20·23	30·96	−13·80	168·49	·09
	7	19·55	·038	18·00	45·07	20·12	30·75	13·73	278·58	1910·03
	12	19·41	·044	17·87	44·73	20·00	30·51	13·64	28·61	1909·97
	17	19·25	·050	17·73	44·38	19·86	30·27	13·55	138·58	·92
	22	19·09	·055	17·53	44·00	19·71	30·02	13·45	248·50	·86
	27	18·92	·060	17·43	43·62	19·55	29·75	13·34	358·36	·80
Mar.	4	18·75	·063	17·27	43·22	19·39	29·48	−13·22	108·16	1909·74
	9	18·58	·065	17·11	42·83	19·22	29·21	13·11	217·90	·69
	14	18·41	·067	16·95	42·43	19·04	28·94	12·99	327·59	·64
	19	18·24	·067	16·80	42·04	18·86	28·68	12·87	77·23	·58
	24	18·07	·067	16·64	41·65	18·68	28·41	12·74	186·81	·53
	29	17·90	·066	16·49	41·27	18·50	28·15	12·62	296·34	·49
Apr.	3	17·74	·064	16·34	40·90	18·33	27·90	−12·50	45·83	1909·45
	8	17·59	·061	16·20	40·54	18·15	27·66	12·38	155·28	·41
	13	17·44	·057	16·06	40·20	17·97	27·42	12·26	264·69	·38
	18	17·30	·053	15·93	39.87	17·80	27·20	12·14	14·07	·35
	23	17·16	·049	15·80	39·56	17·64	26·99	12·03	123·42	·32
	28	17·03	·044	15·68	39·27	17·47	26·79	11·92	232·74	1909·29
May	3	16·92	0·039	15·57	38·99	17·32	26·60	−11·81	342·03	

		Enceladus. a_2	b_2	l_2-L	Diff.	*Tethys.* a_3	b_3	l_3-L	Diff.
1885.		″	″	°	°	″	″	°	°
Sept.	15	35·58	−15·36	213·66	1313·47	44·05	−19·01	204·91	953·27
	20	35·90	15·47	87·13	·52	44·44	19·15	78·18	·31
	25	36·22	15·58	320·65	·56	44·84	19·29	311·49	·36
	30	36·55	15·70	194·21	·61	45·25	19·44	184·85	·40
Oct.	5	36·89	−15·83	67·82	1313·66	45·67	−19·60	58·25	953·46
	10	37·24	15·97	301·48	·70	46·10	19·76	291·71	·50
	15	37·58	16·11	175·18	·76	46·53	19·94	165·21	·55
	20	37·93	16·25	48·94	·80	46·95	20·12	38·76	·60
	25	38·27	16·40	282·74	·84	47·37	20·30	272·36	·65
	30	38·60	16·55	156·58	·89	47·79	20·49	146·01	·70
Nov.	4	38·92	−16·70	30·47	1313·94	48·19	−20·68	19·71	953·73
	9	39·23	16·85	264·41	1313·97	48·57	20·86	253·44	·78
	14	39·52	17·00	138·38	1314·01	48·93	21·05	127·22	·82

		Enceladus.				Tethys.			
		a_2	b_2	l_2-L	Diff.	a_2	b_2	l_2-L	Diff.
1885.		″	″	°	°	″	″	°	°
Nov.	19	39·79	−17·15	12·39	1314·04	49·26	−21·22	1·04	953·85
	24	40·04	17·28	246·43	·07	49·56	21·39	234·89	·88
	29	40·25	17·41	120·50	·09	49·83	21·55	108·77	·91
Dec.	4	40·44	−17·53	354·59	1314·11	50·06	−21·70	342·68	953·92
	9	40·59	17·64	228·70	·11	50·24	21·84	216·60	·94
	14	40·70	17·73	102·81	·13	50·38	21·95	90·54	·95
	19	40·78	17·81	336·94	·12	50·48	22·05	324·49	·95
	24	40·81	17·87	211·06	·11	50·52	22·12	198·44	·94
	29	40·81	17·91	85·17	·09	50·51	22·18	72·38	·93
1886.									
Jan.	3	40·76	−17·94	319·26	1314·07	50·46	−22·21	306·31	953·91
	8	40·67	17·95	193·33	·05	50·35	22·22	180·22	·89
	13	40·55	17·93	67·38	1314·01	50·20	22·20	54·11	·85
	18	40·39	17·90	301·39	1313·97	50·00	22·16	287·96	·82
	23	40·20	17·85	175·36	·93	49·76	22·10	161·78	·78
	28	39·97	17·79	49·29	·88	49·48	22·02	35·56	·73
Feb.	2	39·72	−17·70	283·17	1313·83	49·17	−21·92	269·29	953·69
	7	39·44	17·61	157·00	·77	48·83	21·80	142·98	·63
	12	39·15	17·50	30·77	·72	48·46	21·66	16·61	·58
	17	38·83	17·38	264·49	·67	48·07	21·51	250·19	·53
	22	38·51	17·25	138·16	·61	47·67	21·35	123·72	·47
	27	38·17	17·11	11·77	·55	47·25	21·18	357·19	·42
Mar.	4	37·82	−16·97	245·32	1313·50	46·82	−21·00	230·61	953·36
	9	37·48	16·82	118·82	·44	46·39	20·82	103·97	·30
	14	37·13	16·66	352·26	·39	45·96	20·63	337·27	·26
	19	36·79	16·51	225·65	·34	45·54	20·43	210·53	·20
	24	36·45	16·35	98·99	·29	45·12	20·24	83·73	·16
	29	36·12	16·19	332·28	·25	44·71	20·04	316·89	·11
Apr.	3	35·79	−16·04	205·53	1313·20	44·31	−19·85	190·00	·07
	8	35·48	15·88	78·73	·16	43·92	19·66	63·07	953·03
	13	35·18	15·73	311·89	·13	43·55	19·47	296·10	952·99
	18	34·89	15·58	185·02	·10	43·19	19·29	169·09	·96
	23	34·62	15·43	58·12	·06	42·86	19·11	42·05	·93
	28	34·36	15·29	291·18	1313·04	42·54	18·93	274·98	952·89
May	3	34·12	−15·15	164·22		42·24	−18·76	147·87	

		Dione.					*Rhea.*		
		a_4	b_4	l_4-L	Diff.	a_5	b_5	l_5-L	Diff.
1885.		″	″	°	°	″	″	°	°
Sept.	15	56·42	−24·35	353·03	657·42	78·79	−34·01	175·89	398·17
	20	56·92	24·52	290·45	·47	79·48	34·24	214·06	·22
	25	57·43	24·70	227·92	·52	80·20	34·50	252·28	·27
	30	57·96	24·90	165·44	·56	80·94	34·77	290·55	·31
Oct.	5	58·50	−25.10	103·00	657·61	81·69	−35·05	328·86	398·36
	10	59·04	25·31	40·61	·66	82·45	35·35	7·22	·41
	15	59·59	25·54	338·27	·71	83·22	35·66	45·63	·47
	20	60·13	25·77	275·98	·76	83·98	35·98	84·10	·51
	25	60·67	26·00	213·74	·81	84·73	36·31	122·61	·56
	30	61·20	26·24	151·55	·85	85·47	36·64	161·17	·60
Nov.	4	61·70	−26·48	89·40	657·90	86·18	−36·98	199·77	398·66
	9	62·20	26·72	27·30	·94	86·87	37·31	238·43	·70
	14	62·66	26·95	325·24	657·98	87·51	37·64	277·13	·74
	19	63·09	27·18	263·22	658·02	88·11	37·96	315·87	·78
	24	63·48	27·40	201·24	·05	88·65	38·27	354·65	·81
	29	63·82	27·61	139·29	·08	89·13	38·55	33·46	·84
Dec.	4	64·11	−27·80	77·37	658·10	89·53	−38·82	72·30	398·87
	9	64·35	−27·97	15·47	·12	89·87	39·06	111·17	·89
	14	64·53	28·12	313·59	·13	90·12	39·26	150·06	·90
	19	64·65	28·24	251·72	·13	90·28	39·43	188·96	·90
	24	64·70	28·34	189·85	·12	90·36	39·57	227·86	·90
	29	64·70	28·40	127·97	·12	90·35	39·67	266·76	·90
1886.									
Jan.	3	64·62	−28·44	66·09	658·10	90·25	−39·72	305·66	398·88
	8	64·49	28·45	3·19	·08	90·06	39·74	344·54	·86
	13	64·29	28·43	302·27	·05	89·78	39·71	23·40	·84
	18	64·04	28·38	240·32	658·02	89·43	39·64	62·24	·80
	23	63·73	28·30	178·34	657·98	89·00	39·53	101·04	·77
	28	63·38	28·20	116·32	·93	88·50	39·38	139·81	·73
Feb.	2	62·98	−28 07	54·25	657·89	87·94	−39·20	178·54	398 68
	7	62·54	27·92	352·14	·84	87·33	38·99	217·22	·63
	12	62·07	27·74	289·98	·79	86·67	38·75	255·85	·58
	17	61·57	27·55	227·77	·73	85·98	38·48	294·43	·54
	22	61·05	27·35	165·50	·68	85·25	38·19	332·97	·48
	27	60·51	27·13	103·18	·63	84·51	37·88	11·45	·42
Mar.	4	59·97	−26·90	40·81	657·58	83·75	−37·56	49·87	398·37
	9	59·42	26·66	338·39	·52	82·98	37·23	88·24	·32
	14	58·87	26·42	275·91	·46	82·21	36·89	126·56	·27

1886.	Dione. a_4	b_4	l_4-L	Diff.	Rhea. a_5	b_5	l_5-L	Diff.
	″	″	°	°	″	″	°	°
Mar. 19	58·32	26·17	213·37		81·45	36·55	164·83	
				657·42				398·22
24	57·79	25·92	150·79		80·70	36·20	203·05	
				·37				·17
29	57·26	25·67	88·16		79·96	−35·85	241·22	
				·33				398·13
Apr. 3	56·75	−25·42	25·49		79·25	35·51	279·35	
				657·29				·08
8	56·25	25·18	322·77		78·55	35·16	317·43	
				·24				·03
13	55·77	24·94	260·01		77·89	34·83	355·46	
				·20				398·00
18	55·32	24·70	197·21		77·25	34·50	33·46	
				·17				397·97
23	54·89	24·47	134·38		76·65	34·17	71·43	
				·13				·93
28	54·48	24·24	72·51		76·08	33·86	109·36	
				657·11				397·90
May 3	54·10	−24·02	8·62		75·55	−33·55	147·26	

Approximate Greenwich Mean Times of conjunctions of the satellites with the centre of the planet.

"n" inferior conjunction with centre, or satellite exactly in the direction of the minor axis of the ring, north, moving from the following to the preceding side.

"s" superior conjunction, or satellite south, moving from the preceding to the following side.

A few conjunctions of *Saturn* with stars are also given, of which those of Dec. 9 and Jan. 9 deserve specially to be watched. As the modern determinations of the star DM 22°1383 are at present not available, and its adopted apparent place for Dec. 9 $6^h\ 27^m\ 6^s{\cdot}04 + 22°\ 25'\ 23''{\cdot}4$ depends upon Ll. 12536, it is doubtful whether the star may not be occulted by the ring. It would be well if the corrections of the star's place, as also of the place of *Saturn*, were ascertained some time beforehand. The predicted conjunctions refer in this case, as in that of μ *Geminorum* on Jan. 9, to the axes of the ring.

1885.	h			1885.	h			1885.	h		
Sept. 15	1·2	Rh.	n.	Sept. 19	14·2	Te.	s.	Sept. 22	9·8	En.	s.
	1·3	Di.	s.		16·0	En.	s.		10·1	Te.	n.
	19·5	Te.	s.	20	12·7	Di.	s.	23	6·4	Di.	s.
16	10·1	Di.	n.		12·8	Te.	n.		8·8	Te.	s.
	18·2	Te.	n.		21·0 or 22·9				18·7	En.	s.
17	7·5	Rh.	s.		☌ with ✱ $8^m{\cdot}8$			24	2·2	Rh.	n.
	16·8	Te.	s.		✱ 58″ south.				7·4	Te.	n.
	19·0	Di.	s.	21	11·5	Te.	s.		11·1	En.	n.
18	15·5	Te.	n.		17·4	En.	n.		15·2	Di.	n.
19	3·8	Di.	n.		20·0	Rh.	s.	25	6·1	Te.	s.
	13·7	Rh.	n.		21·5	Di.	n.		20·0	En.	n.

1885.	h		
Sept. 26	0·1	Di.	s.
	4·8	Te.	n.
	8·5	Rh.	s.
	12·5	En.	s.
27	3·4	Te.	s.
	9·0	Di.	n.
	21·4	En.	s.
28	2·2	Te.	n.
	13·8	En.	n.
	14·7	Rh.	n.
	17·8	Di.	s.
29	0·7	Te.	s.
	22·7	En.	n.
	23·4	Te.	n.
30	2·7	Di.	n.
	15·1	En.	s.
	20·9	Rh.	s.
	22·0	Te.	s.
Oct. 1	11·5	Di.	s.
	20·7	Te.	n.
2	16·5	En.	n.
	19·4	Te.	s.
	20·4	Di.	n.
3	3·1	Rh.	n.
	8·9	En.	s.
	18·0	Te.	n.
4	5·2	Di.	s.
	16·7	Te.	s.
	17·8	En.	s.
	21·4	Mi.	s.
5	9·4	Rh.	s.
	10·2	En.	n.
	14·0	Di.	n.
	15·3	Te.	n.
	20·0	Mi.	s.
6	14·0	Te.	s.
	18·6	Mi.	s.
	19·1	En.	n.
	22·9	Di.	s.
7	11·6	En.	s.
Oct. 7	12·6	Te.	n.
	15·6	Rh.	n.
	17·2	Mi.	s.
8	7·7	Di.	n.
	11·3	Te.	s.
	15·9	Mi.	s.
	20·5	En.	s.
9	9·9	Te.	n.
	12·9	En.	n.
	14·5	Mi.	s.
	16·6	Di.	s.
	21·8	Rh.	s.
10	8·6	Te.	s.
	13·1	Mi.	s.
	21·8	En.	n.
11	1·4	Di.	n.
	7·2	Te.	n.
	11·7	Mi.	s.
	14·2	En.	s.
12	4·0	Rh.	n.
	5·9	Te.	s.
	10·3	Di.	s.
	21·6	Mi.	n.
	23·1	En.	s.
13	4·5	Te.	n.
	15·6	En.	n.
	19·1	Di.	n.
	20·3	Mi.	n.
14	3·2	Te.	s.
	10·3	Rh.	s.
	18·9	Mi.	n.
15	1·9	Te.	n.
	4·0	Di.	s.
	16·9	En.	s.
	17·5	Mi.	n.
16	0·5	Te.	s.
	9·3	En.	n.
	12·8	Di.	n.
	16·1	Mi.	n.
	16·5	Rh.	n.
Oct. 16	23·2	Te.	n.
17	14·7	Mi.	n.
	18·2	En.	n.
	21·6	Di.	s.
	21·8	Te.	s.
18	10·6	En.	s.
	13·3	Mi.	n.
	20·5	Te.	n.
	22·7	Rh.	s.
19	6·5	Di.	n.
	12·0	Mi.	n.
	19·1	Te.	s.
	19·5	En.	s.
20	12·0	En.	n.
	15·3	Di.	s.
	17·8	Te.	n.
	21·9	Mi.	s.
21	4·9	Rh.	n.
	16·4	Te.	s.
	20·5	Mi.	s.
	20·8	En.	n.
22	0·2	Di.	n.
	13·3	En.	s.
	15·1	Te.	n.
	19·1	Mi.	s.
23	9·0	Di.	s.
	11·1	Rh.	s.
	13·7	Te.	s.
	17·7	Mi.	s.
	22·2	En.	s.
24	12·4	Te.	n.
	14·6	En.	n.
	16·3	Mi.	s.
	17·8	Di.	n.
25	11·0	Te.	s.
	15·0	Mi.	s.
	17·3	Rh.	n.
	23·5	En.	n.
26	2·6	Di.	s.
	9·7	Te.	n.

1885.	h		
Oct. 27	8·3	Te.	s.
	11·5	Di.	n.
	23·5	Rh.	s.
28	7·0	Te.	n.
	20·3	Di.	s.
29	5·6	Te.	s.
30	4·3	Te.	n.
	5·2	Di.	n.
	5·7	Rh.	n.
	18·6	En.	s.
	19·3	Mi.	n
31	2·9	Te.	s.
	11·0	En.	n.
	14·0	Di.	s.
	18·0	Mi.	n.
Nov. 1	1·6	Te.	n.
	11·9	Rh.	s.
	16·6	Mi.	n.
	19·9	En.	n.
	22·9	Di.	n.
2	0·22	Te.	s.
	12·3	En.	s.
	15·2	Mi.	n.
	22·9	Te.	n.
3	7·7	Di.	s.
	13·8	Mi.	n.
	18·0	Rh.	n.
	21·2	En.	s.
	21·5	Te.	s.
4	12·4	Mi.	n.
	13·7	En.	n.
	16·5	Di.	n.
	20·2	Te.	n.
5	6·1	En.	s.
	11·0	Mi.	n.
	18·8	Te.	s.
6	0·2	Rh.	s.
	1·4	Di.	s.
	15·0	En.	s.
	17·5	Te.	n.

1885.	h		
Nov. 6	21·0	Mi.	s.
7	7·4	En.	n.
	10·2	Di.	n.
	16·1	Te.	s.
	19·6	Mi.	s.
8	6·4	Rh.	n.
	14·8	Te.	n.
	16·3	En.	n.
	18·2	Mi.	s.
	19·0	Di.	s.
9	8·7	En.	s.
	13·4	Te.	s.
	16·8	Mi.	s.
10	3·8	Di.	n.
	12·0	Te.	n.
	12·6	Rh.	s.
	15·4	Mi.	s.
	17·6	En.	s.
11	10·0	En.	n.
	10·7	Te.	s.
	12·7	Di.	s.
	14·0	Mi.	s.
12	9·3	Te.	n.
	12·6	Mi.	s.
	18·8	Rh.	n.
	18·9	En.	n.
	21·5	Di.	n.
13	8·0	Te.	s.
	11·3	Mi.	s.
	11·4	En.	s.
14	6·3	Di.	s.
	6·6	Te.	n.
	9·9	Mi.	s.
	20·2	En.	s.
15	0·9	Rh.	s.
	5·3	Te.	s.
	12·7	En.	n.
	15·2	Di.	n.
	19·8	Mi.	n.
16	3·9	Te.	n.

1885.	h		
Nov. 16	18·4	Mi.	n.
	21·5	En.	n.
17	0·0	Di.	s.
	2·6	Te.	s.
	7·1	Rh.	n.
	14·0	En.	s.
	17·0	Mi.	n.
18	1·2	Te.	n.
	2·4 or 4·3 ☌ with * $8^m·8$ * 62" south.		
	6·4	En.	n.
	8·8	Di.	n.
	15·6	Mi.	n.
	23·9	Te.	s.
19	13·3	Rh.	s.
	14·2	Mi.	n.
	15·3	En.	n.
	17·6	Di.	s.
	22·5	Te.	n.
20	7·7	En.	s.
	12·9	Mi.	n.
	21·2	Te.	s.
21	2·5	Di.	n.
	19·4	Rh.	n.
	19·8	Te.	n.
22	11·3	Di.	s.
	18·4	Te.	s.
23	17·1	Te.	n.
	20·1	Di.	n.
24	1·6	Rh.	s.
	15·7	Te.	s.
25	4·9	Di.	s.
	14·4	Te.	n.
26	7·8	Rh.	n.
	11·7	En.	n.
	13·0	Te.	s.
	13·8	Di.	n.
	15·8	Mi.	s.
27	11·7	Te.	n.

1885.	h		
Nov. 27	14·4	Mi.	s.
	20·6	En.	n.
	22·6	Di.	s.
28	10·3	Te.	s.
	13·0	En.	s.
	13·1	Mi.	s.
	13·9	Rh.	s.
29	5·4	En.	n.
	7·4	Di.	n.
	9·0	Te.	n.
	11·7	Mi.	s.
30	7·6	Te.	s.
	10·3	Mi.	s.
	14·3	En.	n.
	16·2	Di.	s.
	20·1	Rh.	n.
Dec. 1	6·2	Te.	n.
	6·7	En.	s.
	8·9	Mi.	s.
2	1·1	Di.	n.
	4·9	Te.	s.
	7·5	Mi.	s.
	15·6	En.	s.
3	2·2	Rh.	s.
	3·5	Te.	n.
	8·1	En.	n.
	9·9	Di.	s.
	17·4	Mi.	n.
4	2·2	Te.	s.
	16·0	Mi.	n.
	16·9	En.	n.
	18·7	Di.	n.
5	0·8	Te.	n.
	8·4	Rh.	n.
	9·4	En.	s.
	14·7	Mi.	n.
	23·5	Te.	s.
6	3·5	Di.	s.
	13·3	Mi.	n.
	18·2	En.	s.

1885.	h		
Dec. 6	22·1	Te.	n.
7	10·7	En.	n.
	11·9	Mi.	n.
	12·3	Di.	n.
	14·5	Rh.	s.
	20·7	Te.	s.
8	10·5	Mi.	n.
	19·4	Te.	n.
	19·5	En.	n.
	21·2	Di.	s.
9	4·4	☌	of
		* $8^m·7$ with prec.	
		edge of ring	
		$y = -8''·0$	
	6·4	☌ of *	
		with centre	
		$y = -12''·2$	
	8·5	☌ of *	
		with foll. edge	
		$y = -16''·4$	
	9·1	Mi.	n.
	12·0	En.	s.
	18·0	Te.	s.
	20·7	Rh.	n.
10	4·4	En.	n.
	6·0	Di.	n.
	7·7	Mi.	n.
	16·7	Te.	n.
11	13·3	En.	n.
	14·8	Di.	s.
	15·3	Te.	s.
	17·6	Mi.	s.
12	2·9	Rh.	s.
	5·7	En.	s.
	14·0	Te.	n.
	16·3	Mi.	s.
	23·6	Di.	n.
13	12·6	Te.	s.
	14·6	En.	s.
	14·9	Mi.	s.

1885.	h		
Dec. 14	7·0	En.	n.
	8·5	Di.	s.
	9·0	Rh.	n.
	11·2	Te.	n.
	13·5	Mi.	s.
15	9·9	Te.	s.
	12·1	Mi.	s.
	15·9	En.	n.
	17·3	Di.	n.
16	8·4	En.	s.
	8·5	Te.	n.
	10·7	Mi.	s.
	15·2	Rh.	s.
17	2·1	Di.	s.
	7·2	Te.	s.
	9·3	Mi.	s.
	17·2	En.	s.
18	5·8	Te.	n.
	10·9	Di.	n.
	21·3	Rh.	n.
19	4·5	Te.	s.
	18·5	En.	n.
	19·7	Di.	s.
20	3·1	Te.	n.
	11·0	En.	s.
21	1·7	Te.	s.
	3·5	Rh.	s.
	4·6	Di.	n.
22	0·4	Te.	n.
	13·4	Di.	s.
	23·0	Te.	s.
23	9·6	Rh.	n.
	21·7	Te.	n.
	22·2	Di.	n.
24	10·9	Mi.	n.
	13·6	En.	s.
	20·3	Te.	s.
25	6·0	En.	n.
	7·0	Di.	s.
	9·5	Mi.	n.

1885.		h		
Dec.	25	15·7	Rh.	s.
		19·0	Te.	n.
	26	8·1	Mi.	n.
		14·9	En.	n.
		15·8	Di.	n.
		17·6	Te.	s.
	27	6·8	Mi.	n.
		7·3	En.	s.
		16·2	Te.	n.
		21·9	Rh.	n.
	28	0·7	Di.	s.
		14·9	Te.	s.
		16·2	En.	s.
		16·7	Mi.	s.
	29	8·7	En.	n.
		9·5	Di.	n.
		13·5	Te.	n.
		15·3	Mi.	s.
	30	4·0	Rh.	s.
		12·2	Te.	s.
		13·9	Mi.	s.
		17·5	En.	n.
		18·3	Di.	s.
	31	10·0	En.	s.
		10·8	Te.	n.
		12·5	Mi.	s.
1886.				
Jan.	1	2·4	En.	n.
		3·1	Di.	n.
		9·5	Te.	s.
		10·2	Rh.	n.
		11·1	Mi.	s.
		18·8	En.	s.
	2	6·2	☌ of * $7^m·5$ * 90″ south	
		8·1	Te.	n.
		9·7	Mi.	s.
		11·3	En.	n.
		11·9	Di.	s.
		3·7	En.	s.

1886.		h		
Jan.	3	6·7	Te.	s.
		8·4	Mi.	s.
		16·3	Rh.	s.
		20·8	Di.	n.
	4	5·4	Te.	n.
		7·0	Mi.	s.
		12·6	En.	s.
	5	4·0	Te.	s.
		5·6	Di.	s.
		16·9	Mi.	n.
		21·5	En.	s.
		22·5	Rh.	n.
	6	2·7	Te.	n.
		13·9	En.	n.
		14·4	Di.	n.
		15·5	Mi.	n.
	7	1·3	Te.	s.
		6·3	En.	s.
		14·1	Mi.	n.
		23·2	Di.	s.
	8	0·0	Te.	n.
		4·6	Rh.	s.
		12·7	Mi.	n.
		15·2	En.	s.
		22·6	Te.	s.
	9	7·7	En.	n.
		8·1	Di.	n.
		11·3	Mi.	n.
		18·6	☌ of μ Gem. w. prec. edge of ring, $y = -22·3$	
		20·7	☌ w. centre $y = -26''·5$	
		21·3	Te.	n.
		22·7	☌ of μ Gem. w. foll. edge $y = -30''·4$	
	10	10·0	Mi.	n.
		10·8	Rh.	n.

1886.		h		
Jan.	10	16·5	En.	n.
		16·9	Di.	s.
		19·9	Te.	s.
	11	8·6	Mi.	n.
		9·0	En.	s.
		18·5	Te.	n.
	12	1·7	Di.	n.
		7·2	Mi.	n.
		16·5	☌ of * $8^m·8$ * 92″ north	
		17·0	Rh.	s.
		17·2	Te.	s.
		17·8	En.	s.
	13	5·8	Mi.	n.
		10·3	En.	n.
		10·5	Di.	s.
		15·8	Te.	n.
		17·1	Mi.	s.
	14	14·5	Te.	s.
		15·7	Mi.	s.
		19·2	En.	n.
		19·3	Di.	n.
		23·1	Rh.	n.
	15	11·6	En.	s.
		13·1	Te.	n.
		14·3	Mi.	s.
	16	4·2	Di.	s.
		11·8	Te.	s.
	17	5·3	Rh.	s.
		10·4	Te.	n.
		13·0	Di.	n.
	18	9·1	Te.	s.
		21·8	Di.	s.
	19	7·7	Te.	n.
		11·4	Rh.	n.
	20	6·3	Te.	s.
		6·6	Di.	n.
	21	5·0	Te.	n.
		15·5	Di.	s.
		15·5	En.	n.

1886.		h		
Jan.	21	17·3	Mi.	n.
		17·6	Rh.	s.
	22	3·6	Te.	s.
		8·0	En.	s.
		15·9	Mi.	n.
	23	0·3	Di.	n.
		2·3	Te.	n.
		14·6	Mi.	n.
		16·9	En.	s.
		23·8	Rh.	n.
	24	0·9	Te.	s.
		9·1	Di.	s.
		9·3	En.	n.
		13·2	Mi.	n.
		23·6	Te.	n.
	25	11·8	Mi.	n.
		18·0	Di.	n.
		18·2	En.	n.
		22·2	Te.	s.
	26	5·9	Rh.	s.
		10·4	Mi.	n.
		10·6	En.	s.
		20·9	Te.	n.
	27	2·8	Di.	s.
		3·1	En.	n.
		9·0	Mi.	n.
		19·5	En.	s.
		19·5	Te.	s.
	28	7·6	Mi.	n.
		11·6	Di.	n.
		11·9	En.	n.
		12·1	Rh.	n.
		18·2	Te.	n.
	29	4·4	En.	s.
		6·3	Mi.	n.
		16·8	Te.	s.
		20·4	Di.	s.
	30	4·9	Mi.	n.
		13·3	En.	s.
		15·5	Te.	n.

1886.		h		
Jan.	30	16·2	Mi.	s.
		18·3	Rh.	s.
	31	5·3	Di.	n.
		5·7	En.	n.
		14·1	Te.	s.
		14·8	Mi.	s.
Feb.	1	12·8	Te.	n.
		13·4	Mi.	s.
		14·1	Di.	s.
		14·6	En.	n.
	2	0·4	Rh.	n.
		7·0	En.	s.
		11·4	Te.	s.
		12·0	Mi.	s.
		22·9	Di.	n.
	3	10·1	Te.	n.
		10·6	Mi.	s.
		15·9	En.	s.
	4	6·6	Rh.	s.
		7·8	Di.	s.
		8·3	En.	n.
		8·7	Te.	s.
		9·3	Mi.	s.
	5	0·8	En.	s.
		7·4	Te.	n.
		7·9	Mi.	s.
		16·6	Di.	n.
		17·2	En.	n.
	6	6·0	Te.	s.
		6·5	Mi.	s.
		9·7	En.	s.
		12·8	Rh.	n.
	7	1·4	Di.	s.
		2·1	En.	n.
		4·7	Te.	n.
		5·1	Mi.	s.
	8	3·3	Te.	s.
		10·3	Di.	n.
		11·0	En.	n.
		15·0	Mi.	n.

1886.		h		
Feb.	8	19·0	Rh.	s.
	9	2·0	Te.	n.
		3·4	En.	s.
		13·7	Mi.	n.
		19·1	Di.	s.
	10	0·6	Te.	s.
		12·3	Mi.	n.
		12·3	En.	s.
		23·3	Te.	n.
	11	1·2	Rh.	n.
		3·9	Di.	n.
		4·7	En.	n.
		10·9	Mi.	n.
		21·2	En.	s.
		21·9	Te.	s.
	12	9·5	Mi.	n.
		12·8	Di.	s.
		13·6	En.	n.
		20·6	Te.	n.
	13	6·1	En.	s.
		7·4	Rh.	s.
		8·1	Mi.	n.
		19·2	Te.	s.
		21·6	Di.	n.
	14	17·9	Te.	n.
	15	6·4	Di.	s.
		7·4	En.	n.
		13·5	Rh.	n.
		16·5	Te.	s.
	16	15·2	Te.	n.
		15·3	Di.	n.
		15·3	Mi.	s.
		16·3	En.	n.
	17	8·7	En.	s.
		13·8	Te.	s.
		13·9	Mi.	s.
		19·7	Rh.	s.
	18	0·1	Di.	s.
		12·5	Te.	n.
		12·5	Mi.	s.

1886.		h		
Feb.	18	17·6	En.	s.
	19	9·0	Di.	n.
		10·0	En.	n.
		11·1	Te.	s.
		11·1	Mi.	s.
	20	1·9	Rh.	n.
		2·5	En.	s.
		9·8	Mi.	s.
		9·8	Te.	n.
		17·8	Di.	s.
	21	8·4	Mi.	s.
		8·4	Te.	s.
		11·4	En.	s.
	22	2·6	Di.	n.
		3·8	En.	n.
		7·0	Mi.	s.
		7·1	Te.	n.
		8·1	Rh.	s.
	23	5·6	Mi.	s.
		5·7	Te.	s.
		11·5	Di.	s.
		12·7	En.	n.
	24	4·2	Mi.	s.
		4·4	Te.	n.
		5·1	En.	s.
		14·3	Rh.	n.
		15·5	Mi.	n.
		20·3	Di.	n.
	25	3·0	Te.	s.
		14·0	En.	s.
		14·2	Mi.	n.
	26	1·7	Te.	n.
		5·2	Di.	s.
		6·5	En.	n.
		12·8	Mi.	n.
		20·5	Rh.	s.
	27	0·3	Te.	s.
		11·4	Mi.	n.
		14·0	Di.	n.
		15·4	En.	n.

1886.		h		
Feb.	27	23·0	Te.	n.
	28	7·8	En.	s.
		10·0	Mi.	n.
		21·7	Te.	s.
		22·9	Di.	s.
Mar.	1	2·8	Rh.	n.
		8·6	Mi.	n.
		16·7	En.	s.
		20·3	Te.	n.
	2	7·3	Mi.	n.
		7·7	Di.	n.
		9·1	En.	n.
		19·0	Te.	s.
	3	1·6	En.	s.
		5·9	Mi.	n.
		9·0	Rh.	s.
		16·5	Di.	s.
		17·6	Te.	n.
	4	4·5	Mi.	n.
		10·5	En.	s.
		15·8	Mi.	s.
		16·3	Te.	s.
	5	1·4	Di.	n.
		2·9	En.	n.
		14·4	Mi.	s.
		14·9	Te.	n.
		15·2	Rh.	n.
	6	10·2	Di.	s.
		11·8	En.	n.
		13·1	Mi.	s.
		13·6	Te.	s.
	7	4·2	En.	s.
		11·7	Mi.	s.
		12·3	Te.	n.
		19·1	Di.	n.
		21·4	Rh.	s.
	8	10·3	Mi.	s.
		10·9	Te.	s.
		13·1	En.	s.
	9	3·9	Di.	s.

1886.		h		
Mar.	9	5·6	En.	n.
		8·9	Mi.	s.
		9·6	Te.	n.
	10	3·6	Rh.	n.
		7·5	Mi.	s.
		8·2	Te.	n.
		12·8	Di.	n.
		14·5	En.	n.
	11	6·2	Mi.	s.
		6·9	Te.	n.
		6·9	En.	s.
		21·6	Di.	s.
	12	5·5	Te.	s.
		9·9	Rh.	s.
	13	4·2	Te.	n.
		6·5	Di.	n.
		8·3	En.	n.
	14	2·9	Te.	s.
		15·3	Di.	s.
		16·1	Rh.	n.
	15	1·5	Te.	n.
		9·6	En.	s.
		12·0	Mi.	n.
	16	0·2	Te.	s.
		0·2	Di.	n.
		2·0	En.	n.
		10·6	Mi.	n.
		22·3	Rh.	s.
		22·8	Te.	n.
	17	9·0	Di.	s.
		9·2	Mi.	n.
		10·9	En.	n.
		21·5	Te.	s.
	18	3·4	En.	s.
		7·8	Mi.	n.
		17·9	Di.	n.
		20·2	Te.	n
	19	4·6	Rh.	n
		18·8	Te.	s.
	20	2·8	Di.	s.

1886.		h		
Mar.	20	17·5	Te.	n.
	21	10·8	Rh.	s.
		11·6	Di.	n.
		13·6	En.	n.
		16·1	Te.	s.
	22	6·1	En.	s.
		13·6	Mi.	s.
		14·8	Te.	n.
		20·5	Di.	s.
	23	12·3	Mi.	s.
		13·5	Te.	s.
		15·0	En.	s.
		17·0	Rh.	n.
	24	5·3	Di.	n.
		7·4	En.	n.
		10·9	Mi.	s.
		12·1	Te.	n.
	25	9·5	Mi.	s.
		10·8	Te.	s.
		14·2	Di.	s.
		23·3	Rh.	s.
	26	8·1	Mi.	s.
		8·7	En.	s.
		9·4	Te.	n.
		23·0	Di.	n.
	27	1·2	En.	n.
		6·7	Mi.	s.
		8·1	Te.	s.
	28	5·5	Rh.	n.
		6·8	Te.	n.
		7·9	Di.	s.
		10·1	En.	n.
	29	5·4	Te.	s.
		16·8	Di.	n.
	30	4·1	Te.	n.
		11·4	En.	s.
		11·8	Rh.	s.
		13·9	Mi.	n.

1886.		h		
Mar.	31	1·6	Di.	s.
		2·7	Te.	s.
		3·9	En.	n.
		12·6	Mi.	n.
Apr.	1	1·4	Te.	n.
		10·5	Di.	n.
		11·2	Mi.	n.
		12·8	En.	n.
		18·1	Rh.	n.
	2	0·1	Te.	s.
		5·3	En.	s.
		9·8	Mi.	n.
		19·3	Di.	s.
		22·7	Te.	n.
	3	8·4	Mi.	n.
		14·2	En.	s.
		21·4	Te.	s.
	4	0·3	Rh.	s.
		4·2	Di.	n.
		6·7	En.	n.
		20·1	Te.	n.
	5	13·1	Di.	s.
		15·5	En.	n.
		18·7	Te.	s.
	6	6·6	Rh.	n.
		7·9	En.	s.
		17·4	Te.	n.
		21·9	Di.	n.
	7	16·1	Te.	s.
	8	6·8	Di.	s.
		9·2	En.	n.
		12·8	Rh.	s.
		14·7	Te.	n.
	9	13·4	Te.	s.
		15·7	Di.	n.
	10	10·6	En.	s.
		12·0	Te.	n.

1886.		h		
Apr.	10	19·1	Rh.	n.
	11	0·5	Di.	s.
		10·7	Te.	s.
	12	9·4	Te.	n.
		9·4	Di.	n.
	13	1·4	Rh.	s.
		8·0	Te.	s.
		18·3	Di.	s.
	14	6·7	Te.	n.
	15	3·1	Di.	n.
		5·4	Te.	s.
		7·6	Rh.	n.
	16	4·0	Te.	n.
		12·0	Di.	s.
	17	2·7	Te.	s.
		13·9	Rh.	s.
		20·9	Di.	n.
	18	1·4	Te.	n.
	19	0·0	Te.	s.
		5·7	Di.	s.
		20·2	Rh.	n.
		22·7	Te.	n.
	20	14·9	Di.	n.
		21·4	Te.	s
	21	20·0	Te.	n.
		23·5	Di.	s.
	22	2·5	Rh.	s.
		18·7	Te.	s.
	23	8·3	Di.	n.
		17·4	Te.	n.
	24	8·7	Rh.	n.
		16·0	Te.	s.
		17·2	Di.	s.
	25	14·7	Te.	n.
	26	2·1	Di.	n.
		13·4	Te.	s.
		15.0	Rh.	s

By means of this list of conjunctions, approximate values of the coordinates x and y, expressed in semi-diameters of the planet's equator, may be easily found for any other time t in the following little table, the argument of which is the interval τ between the time t and the time of the nearest preceding or following conjunction.

τ	*Mimas.*		*Enceladus.*		*Tethys.*		*Dione.*		*Rhea.*	
h	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	x_5	y_5
0	0·0	1·4	0·0	1·8	0·0	2·3	0·0	2·9	0·0	4·0
1	0·9	1·4	0·8	1·7	0·7	2·2	0·6	2·9	0·5	4·0
2	1·7	1·2	1·5	1·7	1·4	2·2	1·2	2·8	1·0	4·0
3	2·3	0·9	2·2	1·5	2·0	2·1	1·8	2·8	1·5	4·0
4	2·8	0·6	2·8	1·3	2·6	1·9	2·4	2·7	2·0	3·9
5	3·1	0·3	3·3	1·0	3·2	1·7	2·9	2·6	2·5	3·8
6	3·1	0·1	3·7	0·7	3·7	1·5	3·5	2·4	3·0	3·8
7	2·9	0·5	3·9	0·4	4·1	1·3	4·0	2·3	3·5	3·7
8	2·5	0·9	4·0	0·1	4·5	1·0	4·4	2·1	4·0	3·6
9					4·7	0·7	4·8	1·9	4·5	3·5
10					4·9	0·4	5·2	1·7	4·9	3·4
11					5·0	0·1	5·6	1·4	5·3	3·2
12							5·8	1·2	5·7	3·1
13							6·1	0·9	6·1	2·9
14							6·2	0·7	6·5	2·8
15							6·3	0·4	6·8	2·6
16							6·4	0·1	7·1	2·4
20									8·2	1·6
27·1									8·9	0·0

The satellites move in the direction of *de*creasing position-angles. They are at their greatest elongations, Mi. $5^{h}{\cdot}7$, En. $8^{h}{\cdot}2$, Te. $11^{h}{\cdot}3$, Di. $16^{h}{\cdot}4$, Rh. $27^{h}{\cdot}1$, before or after the times of conjunction. Observers who are desirous to follow the motions of the satellites will do well to lay down the data of the table graphically on a sufficiently large scale, so that, by marking the corresponding times for the night of observing, they may get information about the places of the satellites at a glance.

Differences of Right Ascension and Declination between the three outer Satellites and the Centre of Saturn.

0^h Gr. 1885.		*Titan.* α_6-A	δ_6-D	*Hyperion.* α_7-A	δ_7-D	*Iapetus.* α_8-A	δ_8-D
		s	″	s	″	s	″
Sept	15	+ 8.50	− 50.2	− 9.92	− 83.4	+27.01	− 19.0
	16	+11.63	− 22.8	− 6.25	− 95.9	29.09	− 8.1
	17	+13.06	+ 8.0	− 2.04	− 100.5	+31.00	+ 2.8
	18	+12.50	+ 37.7	+ 2.34	− 97.5	32.75	13.8
	19	+ 9.98	+ 61.5	+ 6.57	− 87.7	+34.32	+ 24.7
	20	+ 5.82	+ 75.4	+10.40	− 72.1	35.70	35.5
	21	+ 0.69	+ 76.8	+13.58	− 51.8	+36.89	+ 46.1
	22	− 4.58	+ 65.5	+15.93	− 28.3	37.88	56.5
	23	− 9.11	+ 43.2	+17.31	− 3.0	+38.66	+ 66.6
	24	−12.18	+ 13.9	+17.59	+ 22.6	38.22	76.4
	25	−13.35	− 17.8	+16.71	+ 46.7	+39.56	+ 85.7
	26	−12.49	− 46.8	+14.63	+ 67.6	39.68	94.5
	27	− 9.78	− 69.1	+11.41	+ 83.3	+39.58	+102.9
	28	− 5.65	− 81.5	+ 7.21	+ 91.9	39.25	110.7
	29	− 0.72	− 82.4	+ 2.31	+ 91.7	+38.70	+117.9
	30	+ 4.34	− 71.8	− 2.84	+ 81.9	37.92	124.5
Oct.	1	+ 8.81	− 50.9	− 7.68	+ 62.6	+36.93	+130.3
	2	+12.01	− 22.6	−11.59	+ 35.5	35.72	135.4
	3	+13.44	+ 9.1	−14.06	+ 3.8	+34.29	+139.8
	4	+12.82	+ 39.5	−14.81	− 28.4	32.66	143.4
	5	+10.17	+ 63.7	−13.85	− 57.5	+30.83	+146.1
	6	+ 5.85	+ 77.6	−11.42	− 80.7	28.81	147.9
	7	+ 0.55	+ 78.7	− 7.90	− 96.3	+26.60	+148.9
	8	− 4.87	+ 66.6	− 3.67	− 103.7	24.23	149.1
	9	− 9.50	+ 43.3	+ 0.85	− 103.1	+21.71	+148.3
	10	−12.61	+ 13.1	+ 5.34	− 95.1	19.04	146.6
	11	−13.75	− 19.4	+ 9.49	− 80.8	+16.24	+144.1
	12	−12.79	− 49.1	+13.05	− 61.3	13.33	140.6
	13	− 9.95	− 71.7	+15.81	− 37.9	+10.33	+136.2
	14	− 5.65	− 84.0	+17.60	− 12.0	7.25	131.0
	15	− 0.54	− 84.5	+18.28	+ 14.7	+ 4.11	+125.0
	16	+ 4.66	− 73.0	+17.76	+ 40.5	+ 0.93	118.2
	17	+ 9.23	− 51.2	+15.99	+ 63.6	− 2.26	+110.5
	18	+12.47	− 21.8	+12.98	+ 81.8	5.46	102.1
	19	+13.86	+ 10.9	+ 8.88	+ 93.2	− 8.64	+ 93.0
	20	+13.12	+ 42.0	+ 3.93	+ 96.0	11.77	83.3
	21	+10.30	+ 66.5	− 1.43	+ 88.7	−14.84	+ 73.0

0^h Gr. 1885.		*Titan.* α_6-A (s)	δ_6-D (″)	*Hyperion.* α_7-A (s)	δ_7-D (″)	*Iapetus.* α_8-A (s)	δ_8-D (″)
Oct.	22	+ 5·80	+ 80·2	− 6·64	+ 71·3	17·81	62·2
	23	+ 0·29	+ 80·6	− 11·06	+ 15·1	− 20·67	+ 50·9
	24	− 5·28	+ 67·5	− 14·09	+ 13·2	23·41	39·2
	25	− 9·99	+ 43·2	− 15·38	− 20·5	− 26·01	+ 27·2
	26	− 13·10	+ 11·7	− 14·87	− 52·0	28·44	15·0
	27	− 14·15	− 21·8	− 12·77	− 78·2	− 30·69	+ 2·6
	28	− 13·05	− 52·1	− 9·36	− 96·5	32·73	− 9·9
	29	− 10·02	− 74·8	− 5·13	− 106·6	− 34·54	− 22·3
	30	− 5·52	− 86·8	− 0·48	− 108·3	36·13	34·7
	31	− 0·23	− 86·6	+ 4·24	− 102·1	− 37·48	− 46·9
Nov.	1	+ 5·12	− 74·1	+ 8·68	− 89·0	38·57	58·8
	2	+ 9·77	− 51·0	+ 12·57	− 70·0	− 39·39	− 70·3
	3	+ 12·98	− 20·4	+ 15·70	− 46·6	39·95	81·4
	4	+ 14·21	+ 13·3	+ 17·86	− 20·2	− 40·24	− 92·0
	5	+ 13·36	+ 45·1	+ 18·89	+ 7·6	40·25	102·0
	6	+ 10·32	+ 69·7	+ 18·68	+ 34·9	− 39·97	− 111·4
	7	+ 5·57	+ 83·0	+ 17·17	+ 60·0	39·41	120·0
	8	− 0·12	+ 82·5	+ 14·36	+ 80·5	− 38·57	− 127·8
	9	− 5·81	+ 68·1	+ 10·36	+ 94·5	37·47	134·8
	10	− 10·55	+ 42·3	+ 5·40	+ 99·8	− 36·11	− 141·0
	11	− 13·60	+ 9·5	− 0·12	+ 94·9	34·50	146·2
	12	− 14·52	− 24·9	− 5·63	+ 79·3	− 32·64	− 150·4
	13	− 13·21	− 55·6	− 10·47	+ 54·1	30·55	153·6
	14	− 9·95	− 78·3	− 14·00	+ 22·0	− 28·26	− 155·8
	15	− 5·24	− 89·8	− 15·79	− 13·0	25·77	157·0
	16	+ 0·23	− 88·5	− 15·68	− 46·6	− 23·09	− 157·2
	17	+ 5·69	− 74·7	− 13·83	− 75·2	20·25	156·3
	18	+ 10·34	− 50·1	− 10·59	− 96·4	− 17·28	− 154·3
	19	+ 13·49	− 18·2	− 6·37	− 109·0	14·18	151·3
	20	+ 14·59	+ 16·5	− 1·61	− 112·8	− 10·98	− 147·4
	21	+ 13·49	+ 48·7	+ 3·28	− 108·2	7·70	142·5
	22	+ 10·19	+ 73·2	+ 7·97	− 96·1	− 4·35	− 136·6
	23	+ 5·21	+ 85·7	+ 12·14	− 77·6	− 0·97	129·8
	24	− 0·66	+ 83·9	+ 15·56	− 54·3	+ 2·42	− 122·2
	25	− 6·43	+ 68·0	+ 18·02	− 27·4	5·81	113·8
	26	− 11·15	+ 40·7	+ 19·33	+ 1·2	+ 9·18	− 104·6
	27	− 14·06	+ 6·7	+ 19·39	+ 29·9	12·49	94·7
	28	− 14·83	− 28·5	+ 18·11	+ 56·6	+ 15·73	− 84·1
	29	− 13·23	− 59·5	+ 15·48	+ 79·1	18·88	73·0
	30	− 9·72	− 81·8	+ 11·59	+ 95·2	+ 21·92	− 61·4
Dec.	1	− 4·79	− 92·3	+ 6·65	+ 102·8	+ 24·83	− 49·4

The rest will be published in the Supplementary Number.

Ephemeris of the Satellite of Neptune, 1885–86. By A. Marth.

P, angle of position of the minor axis of the satellite's apparent orbit, in the direction of superior conjunction.

a, b, major and minor semi-axis of the apparent orbit.

$u-U$, longitude of the satellite in its orbit, reckoned from the point which is in superior conjunction with the planet or in opposition to the Earth.

U + 180°, planetocentric longitude of the Earth, reckoned in the satellite's orbit from the ascending node on the celestial equator.

B, planetocentric latitude of the Earth above the plane of the satellite's orbit.

0^h Gr.	P	a	b	$u-U$	Diff.	U	B
1885.	°	″	″	°	°	°	°
Sept. 15	322·20	16·68	7·81	156·14	612·49	133·42	27·94
25	322·10	16·76	7·84	48·63	·44	133·55	27·90
Oct. 5	321·97	16·83	7·86	301·07	·39	133·73	27·84
15	321·80	16·89	7·87	193·46	·34	133·94	27·76
25	321·61	16·94	7·86	85·80	·31	134·19	27·66
Nov. 4	321·41	16·97	7·85	338·11	·29	134·47	27·55
14	321·19	16·98	7·82	230·40	·27	134·76	27·44
24	320·97	16·97	7·79	122·67	·28	135·04	27·32
Dec. 4	320·77	16·94	7·74	14·95	·29	135·32	27·20
14	320·58	16·90	7·69	267·24	·31	135·57	27·09
24	320·41	16·84	7·64	159·55	·34	135·80	26·99
1886.							
Jan. 3	320·27	16·77	7·59	51·89	612·39	135·98	26·90
13	320·17	16·69	7·54	304·28	·43	136·11	26·84
23	320·11	16·60	7·49	196·71	·49	136·19	26·79
Feb. 2	320·10	16·51	7·44	89·20	·55	136·21	26·77
12	320·12	16·41	7·40	341·75	·60	136·17	26·78
22	320·19	16·32	7·36	234·35	·66	136·07	26·81
Mar. 4	320·30	16·23	7·33	127·01	612·72	135·92	26·86
14	320·45	16·15	7·31	19·73		135·72	26·93

The values of P, a, b, and $u-U$ are to be interpolated for the times for which the apparent positions of the satellite are required, and the position-angles p and distances s are then found by means of the equations

$$s \sin (P-p) = a \sin (u-U)$$

$$s \cos (P-p) = b \cos (u-U).$$

The satellite moves in the direction of decreasing position-angles, and will be at its greatest elongations and at its conjunctions with the planet at the following hours, Greenwich mean time.

	nf. Elong.			Sup. Conj.			sp. Elong.			Inf. Conj.	
p=		P+90°			P			P−90°			P−180°
s=		a			b			a			b
1885.		h			h			h			h
Sept.	16	20·6	Sept.	18	7·9	Sept.	19	19·1	Sept.	21	6·4
	22	17·7		24	4·9		25	16·2		27	3·5
	28	14·7		30	2·0	Oct.	1	13·3	Oct.	3	0·6
Oct.	4	11·8	Oct.	5	23·1		7	10·4		8	21·6
	10	8·9		11	20·2		13	7·4		14	18·7
	16	6·0		17	17·3		19	4·5		20	15·8
	22	3·1		23	14·4		25	1·6		26	12·9
	28	0·2		29	11·5		30	22·7	Nov.	1	10·0
Nov.	2	21·3	Nov.	4	8·6	Nov.	5	19·9		7	7·1
	8	18·4		10	5·7		11	17·0		13	4·2
	14	15·5		16	2·8		17	14·1		19	1·4
	20	12·6		21	23·9		23	11·2		24	22·5
	26	9·7		27	21·0		29	8·3		30	19·6
Dec.	2	6·9	Dec.	3	18·1	Dec.	5	5·4	Dec.	6	16·7
	8	4·0		9	15·2		11	2·5		12	13·8
	14	1·1		15	12·4		16	23·6		18	10·9
	19	22·2		21	9·5		22	20·7		24	8·0
	25	19·3		27	6·6		28	17·8		30	5·1
	31	16·4	Jan.	2	3·7	Jan.	3	14·9	Jan.	5	2·2
1886. Jan.	6	13·5		8	0·7		9	12·0		10	23·3
	12	10·6		13	21·8		15	9·1		16	20·4
	18	7·6		19	18·9		21	6·2		22	17·5
	24	4·7		25	16·0		27	3·2		28	14·5
	30	1·8		31	13·0	Feb.	2	0·3	Feb.	3	11·6
Feb.	4	22·8	Feb.	6	10·1		7	21·4		9	8·6
	10	19·9		12	7·1		13	18·4		15	5·7
	16	16·9		18	4·2		19	15·4		21	2·7
	22	14·0		24	1·2		25	12·5		26	23·7
	28	11·0	Mar.	1	22·2	Mar.	3	9·5	Mar.	4	20·8

Errata in Mr. Thackeray's paper on the Diameters of the Sun and Moon.

Page 391, lines 15, 11, and 9 from bottom, *for* 1853, 1854, and 1857, *read* 1854, 1855, and 1856.

" 392, line 7, *for* 1877 till 1880, *read* 1878 till 1880.

" 395, in sixth column under "Lynn," the mean annual values should be

1875	...	...	$-2''{\cdot}00_{20}$
1876	...	...	$-1{\cdot}14_{10}$
1877	...	...	$-1{\cdot}23_{9}$

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. SUPPLEMENTARY NUMBER. No. 9

On Al-Sūfi and Ptolemy's Catalogues. By Prof. H. C. F. C. Schjellerup.

(*Extract from a Letter to Mr. Knobel.*)

"Having read your article in the number for June last of the *Monthly Notices*, and especially your remarks (page 419) on the great care which has always been taken by the scribes in ruling the necessary columns for entering the catalogues of stars in the two MSS. of Al-Sūfi at the British Museum and in the India Office Library, I am afraid that you use these MSS. in a perfectly wrong manner. The star magnitudes in these catalogues are evidently encumbered with slips of the pen and frequent forgetfulness of the qualifying letters.

"My own 'Tableau synoptique' as well as 'les grandeurs' in the special catalogues are only based on the 'description' which precedes the catalogue, where the magnitudes are expressed in *words*. If, therefore, the statements of the magnitudes in the MSS. in question are to be compared, it must be done exclusively by having recourse to the 'description.' In this way all my statements in the 'Tableau synoptique' can be controlled, even if by a misprint they should not be in conformity with the statement in the special catalogue. For instance, when (page 421) you meet with 3-2 for No. 4 *Cygni*, and you see that the catalogue contains 3, by turning to page 79 in my book you will be convinced that the catalogue is wrong, for the description says, 'elle est des grandes de la troisième grandeur.'

"I take this opportunity to complain of a remark of yours in the *Monthly Notices*, January last, page 149.

"'Professor Schjellerup, in his Al-Sūfi, gives Ptolemy's cor-

rect description to the stars in question, and also to the red star *α Tauri*, but he appends the Arabic word الكخوصي, which he translates "rouge," or "rougeâtre." Dr. Rieu, the Keeper of Oriental MSS. at the British Museum, and Dr. Redhouse inform me *there is no such Arabic word implying colour.* In fact, Professor Schjellerup translates the word as it ought to be, his Arabic MS. having an untranslatable word.'

"Dr. Redhouse is here in error. Turn up only Freytagii Lexicon Arabico-Latinum, s.v. خوص, and you will find 'ornavit laminis aureis (coronam).' I think that a designation of *α Tauri* as a 'golden' star is more proper than Dr. Redhouse's 'chest complaint look' about the same star.

"I should be glad if you would kindly cause the above to be inserted in an early number of the *Monthly Notices.*

"*Copenhagen:*
1885, Sept. 23."

Note on the above. By E. B. Knobel.

The remarks on page 419 of the June *Notices* quoted by Professor Schjellerup were not intended to be limited to MSS. of Al-Sūfi, but to apply to all the Oriental MSS., both Arabic and Persian, of Ptolemy, Al-Sūfi, and Ulugh Beigh, which I had examined. The object of the paper was *solely* to show that in these MSS. errors of transcriber and translator are so frequent and so rife that we are not yet in a position to assume that any differences we find in the star magnitudes of Al-Sūfi and Ulugh Beigh may not be due to such errors.

Professor Schjellerup takes exception to my remarks (p. 149 of the January *Notices*) on his translation of the Arabic word الكخوصي as "rouge" or "rougeâtre."

The word خوص, which he gives as his authority from Freytag, is one which I had carefully considered and discussed with Dr. Redhouse when preparing the paper. I hardly think that his translation of it as "golden" can be at all sustained. The noun خُوص means "the leaves or the fronds of the date palm," and the verb خوّص (with reduplication of the second letter) means "put forth leaves (the tree)." In Lane's dictionary the sentence in Freytag, quoted by Professor Schjellerup, is thus given: "he ornamented (the crown) with plates of gold of the width of palm leaves." The use of the word خوص here refers to the *shape*, and not to any colour. I think it extremely unlikely that the solution of the difficulty can be found in the word خوص as the authorities I have consulted do not agree with Professor Schjellerup that it can be used in a sense implying colour.

The Horizontal and Vertical Diameters of the Sun as observed with the Greenwich Transit Circle.

By W. G. Thackeray.

(Communicated by A. M. W. Downing.)

The following table is formed by taking from one of the sections of the *Greenwich Observations* the daily errors of the *Nautical Almanac* horizontal diameter of the Sun, as given by each of the regular observers for the years 1861–83, and ranging them under each observer's name. The tabular figures represent the mean annual error, with the number of observations on which the value depends, subscribed.

Tabular Errors of the Sun's Horizontal Diameter as computed in the "Nautical Almanac."

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	″	″	″	″		″	″	″	″
1861	$+0.036_{11}$	$+0.080_{17}$	$+0.091_{7}$	-0.013_{16}					
1862	$+0.062_{5}$	$+0.145_{13}$	$+0.176_{11}$	$+0.047_{16}$					
1863	$+0.058_{12}$	$+0.123_{25}$	$+0.227_{22}$	$+0.007_{20}$					
1864	$+0.036_{15}$	$+0.054_{23}$	$+0.174_{19}$	$+0.011_{25}$					
1865	$+0.050_{14}$	$+0.093_{22}$	$+0.190_{18}$	-0.009_{24}					
1866	$+0.036_{14}$	$+0.113_{20}$	$+0.136_{17}$	-0.028_{16}					
1867	$+0.068_{12}$	$+0.114_{17}$	$+0.166_{13}$	$+0.056_{11}$					
1868	$+0.052_{18}$	$+0.074_{16}$	$+0.208_{10}$	$+0.027_{23}$					
1869	$+0.097_{12}$	$+0.100_{18}$	$+0.187_{12}$	$+0.031_{15}$					
... ...		$+0.091_{17}$ +	0.194_{20}	$+0.041_{17}$	$+0.100_{14}$				

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis	Hollis.
	″	″	″	″	″	″	″	″	″
1871		$+0.094_{11}$	$+0.144_{11}$	$+0.042_{11}$	$+0.060_{21}$				
1872		$+0.157_{21}$	$+0.138_{14}$	$+0.042_{16}$	$+0.052_{22}$				
1873		$+0.102_{17}$		$+0.007_{16}$	$+0.073_{20}$	$+0.165_{23}$			
1874		$+0.092_{12}$		$+0.058_{18}$	$+0.043_{19}$	$+0.063_{17}$			
1875				$+0.038_{13}$	$+0.063_{15}$	$+0.117_{14}$	$+0.109_{13}$		
1876				$+0.054_{13}$	$+0.076_{10}$	$+0.115_{21}$	$+0.087_{20}$		
1877				$+0.013_{13}$	$+0.101_{6}$	$+0.104_{15}$	$+0.026_{13}$		
1878				$+0.053_{12}$		$+0.113_{16}$	$+0.028_{11}$		
1879				$+0.033_{12}$		$+0.098_{12}$	$+0.054_{9}$		
1880				-0.015_{15}		$+0.092_{24}$	-0.013_{9}		
1881				-0.020_{20}		$+0.069_{22}$	$+0.006_{16}$	$+0.150_{25}$	
1882						$+0.016_{13}$	$+0.042_{19}$	$+0.097_{17}$	$+0.108_{20}$
1883						$+0.039_{20}$	$+0.008_{23}$	$+0.069_{19}$	$+0.047_{17}$
Means	$+0.054_{113}$	$+0.103_{232}$	$+0.175_{177}$	$+0.020_{159}$	$+0.065_{130}$	$+0.097_{197}$	$+0.039_{143}$	$+0.110_{61}$	$+0.080_{37}$
Probable Error of Mean	± 0.003	± 0.003	± 0.004	± 0.002	± 0.004	± 0.003	± 0.004	± 0.007	± 0.009
Probable Error of a Single Observn.	± 0.036	± 0.051	± 0.056	± 0.038	± 0.050	± 0.048	± 0.051	± 0.052	± 0.055

Mean of all the observers ... ... $+0''.0771_{1440}$

Taking the mean errors of the vertical diameter, as given by the same observers from my former paper in the June number, and multiplying by 14 to convert into seconds of arc, we get—

	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.	Mean Obs.
Errors of Vertical Diameter	$+2''.28$	$-0''.19$	$+3''.13$	$+1''.65$	$-1''.59$	$+1''.70$	$+1''.01$	$+0''.48$	$+0''.15$	$+1''.11$
Errors of Horizon. Diameter	+0.76	+1.44	+2.42	+0.28	+0.91	+1.15	+0.45	+1.54	+1.12	+1.08
Vert. Diam. – Horizon. Diam.	−1.52	+1.63	−0.71	−1.37	+2.50	−0.55	−0.56	+1.06	+0.97	+0.03

The chief points of interest involved in these results seem to be—

1. The several observers differ in their estimate of the Sun's vertical diameter by as much as $4''.8$, whereas they only differ $2''.2$ in their estimate of the horizontal diameter.

2. While the "mean observer" makes the Sun quite circular, none of the observers themselves do so, but are equally divided as to which diameter is the larger, the range amounting to $4''$.

3. It would appear as if observers find greater difficulty in placing the moveable wires of the Z. D. micrometer, so as to form a contact with the limb, which is virtually at rest in the direction of measurement, than they do in estimating the moment when the moving limb forms a contact with the fixed wires. More time to think produces greater divergence of opinions.

On a Suspected New Variable Star in Corona Borealis.
By G. F. Chambers.

In Birmingham's very interesting and valuable Catalogue of Red Stars (*Transactions, Royal Irish Academy*, vol. xxvi., p. 281) there occurs under the number 361 an entry as follows :—

> " 'Cape Obs.: fine ruby; 9·5.' *B's Obs.*: 1873, March 14 and 19, and April 20, not seen. 1874, April 10, not seen. *Dublin Obs.*: Ball, 1876, Aug. 1, no star of 8·5 mag. in this position."

The position given by Birmingham is (for 1885) as follows :—

R.A. $15^h\ 45^m\ 26^s$. Decl. $+39°\ 54'·7$.

In the course of a systematic re-observation of all Birmingham's red stars, which I have been carrying on for some years past, I came to Birmingham's 361st object on 1885, August 13, and setting my telescope to the assigned place I found at once in the field a conspicuously red star which could not possibly have escaped the notice of two such experienced observers as Mr. Birmingham and Dr. Ball had it been visible in 1873–4–6.

I will here transcribe the entry made in my Observatory Book under 1885, August 13 :—

" A star, distinctly red, found in $\delta + 39°\ 55'$ and slightly, say 32^s, *f*, as estimated by reticulated micrometer, the place assigned for 361 Birm. Colour, most evident; mag. say 8. The field contained an equilateral triangle of stars, one side of which was nearly in the Meridian ; the suspected var. was about two-fifths the distance from corner to corner of the triangle, reckoning from N. to S. The most southerly star and the suspected var. were about equal—perhaps the star slightly the brighter—but the other two stars of the triangle were each somewhat fainter."

I was thus particular in writing down these details in order to facilitate the re-observation of the group next year after conjunction with the Sun. The Declination circle of my instrument (6-inch Grubb, power 75) was in good adjustment, and I can rely on the value given above for the Declination of the star, but I am less able to guarantee the exactness of the R.A. to a few seconds. It is to be noted, however, that Birmingham's Catalogue contains no star anywhere within reach which I could have mistaken.

Sir J. Herschel having seen this star at the Cape about 1830, and Birmingham and Ball having missed it 1873–6, I hope it will hereafter appear that I was justified in reporting it as an addition to our list of known variables. I have examined the star on several occasions since August 13, but I am not as yet able to feel sure that it has undergone any change.

Northfield Grange Observatory,
Eastbourne, Sussex:
1885, *Sept.* 28.

Observations of Comet 1884 I. (Pons-Brooks) made at the Royal Observatory, Cape of Good Hope.

(Communicated by D. Gill, LL.D., F.R.S., H.M. Astronomer.)

1884.	Cape Mean Time.	Comet − ✱ Δα	Comet − ✱ Δδ	No. of Comp.	Observer.	Comet's App. R.A.	Log. par. factor.	Comet's App. Dec.	Log. par. factor.	Reductions to Apparent Place		Comp. Star.
	h m s	m s	′ ″			h m s				s	″	
Jan. 16	8 38 38·2	−2 3·65		4	F	23 23 28·29	8·729			−0·08	+ 0·8	1
	8 47 0·6		+5 55·6	3	F			− 4 37 19·7	9·731$_n$			1
24	8 45 13·2	−0 51·39	+5 34·6	4·4	F	0 9 8·20	8·744	−17 35 56·8	9·657$_n$	−0·12	− 4·9	2
	8 53 42·2	−0 52·31		8	F	0 9 7·28	8·749					2
26	8 44 29·2	−3 27·81	−2 50·0	8·8	F	0 11 32·46	8·772	−20 37 19·8	9·710$_n$	−0·15	− 6·0	3
28	9 7 36·1	+3 25·46	+1 0·2	6·7	F	0 19 25·31	8·773	−23 16 11·1	9·654$_n$	−0·21	− 6·7	4
29	8 44 31·5	−1 30·04	−3 37·2	8·8	F	0 23 4·33	8·767	−24 29 29·9	9·612$_n$	−0·21	− 7·4	5
Feb. 2	8 37 5·3	−0 25·57	−3 12·9	3·3	F	0 36 40·74	8·786	−29 0 57·2	9·580$_n$	−0·29	− 8·9	6
	8 46 21·4	−6 18·13	+6 26·9	2·2	F	0 36 42·45	8·790	−29 1 20·1	9·596$_n$	−0·26	− 9·3	7
4	8 25 35·6	+1 24·83	−2 0·1	8·8	F	0 42 47·55	8·783	−31 1 38·0	9·515$_n$	−0·34	− 9·5	8
6	8 27 16·6	+0 4·11	+3 58·1	20·20	F	0 48 32·92	8·795	−32 54 4·8	9·504$_n$	−0·38	−10·1	9
7	8 33 44·0	−2 39·04	−3 42·30	8·8	F	0 51 17·98	8·804	−33 47 42·0	9·513$_n$	−0·38	−10·5	10
9	8 51 35·7	+0 3·21		12	F	0 56 34·50	8·823			−0·42	−11·1	11
	9 3 28·4		−8 1·6	·10	F			−35 29 26·7	9·577$_n$			11

1884.		Cape Mean Time.	Comet − ⋆ Δα	Comet − ⋆ Δδ	No. of Comp.	Observer.	Comet's App. R.A.	Log. par. factor	Comet's App. Dec.	Log. par. factor.	Reductions to Apparent Place.		Comp. Star.
		h m s	m s	″			h m s		° ′ ″		s	″	
Feb.	10	8 36 49·0	−1 56·86	+0 54·5	12·12	F	0 59 2·90	8·821	−36 16 9·5	9·503$_n$	−0·46	−11·2	12
	12	8 50 55·2	−0 36·28	−0 24·5	10·10	F	1 3 53·55	8·837	−37 47 1·3	9·534$_n$	−0·52	−11·4	13
	15	8 25 36·4	+0 52·97	+1 35·2	10·10	F	1 10 39·46	8·841	−39 51 15·7	9·445$_n$	−0·59	−12·1	14
	17	8 33 35·0	−2 5·19	−2 38·9	6·6	F	1 14 56·84	8·855	−41 7 43·1	9·468$_n$	−0·65	−12·1	15
	18	8 50 39·8	−1 22·09	+7 48·8	12·12	F	1 17 4·81	8·866	−41 44 48·5	9·523$_n$	−0·68	−12·2	16
	19	8 35 31·4	−2 43·13	+1 21·5	4·4	F	1 19 7·41	8·865	−42 19 49·1	9·472$_n$	−0·70	−12·4	17
	22	9 15 5·5	+1 54·24	−6 16·1	6·6	F	1 25 13·13	8·886	−44 1 14·3	9·597$_n$	−0·81	−12·2	18
	24	7 35 0·1	+0 6·69	−4 50·8	12·12	F	1 29 0·92	8·853	−45 1 40·0	9·173$_n$	−0·86	−12·4	19
	25	8 0 54·0	−0 46·35	−8 16·4	12·12	F	1 30 59·92	8·877	−45 32 20·5	9·324$_n$	−0·89	−12·5	20
	26	8 22 21·8	−2 11·65	−2 29·6	10·10	F	1 32 58·16	8·893	−46 2 9·7	9·424$_n$	−0·91	−12·6	21
	27	8 10 44·3	−1 51·73	+5 12·1	10·10	F	1 34 53·73	8·892	−46 30 39·3	9·373$_n$	−0·97	−12·3	22
	29	8 28 5·4	−2 41·55	+5 10·3	10·10	F	1 38 48·25	8·908	−47 26 36·7	9·447$_n$	−1·01	−12·7	23
Mar.	2	8 19 4·1	−2 58·67	+3 59·7	12·12	F	1 42 40·76	8·914	−48 19 50·1	9·418$_n$	−1·07	−12·7	24
	3	7 55 18·1	+0 46·75	−0 53·9	6·6	F	1 44 36·51	8·909	−48 45 24·0	9·306$_n$	−1·13	−12·2	25
	4	7 59 36·2	−1 10·03	+0 50·6	12·12	F	1 46 35·40	8·915	−49 10 55·7	9·328$_n$	−1·15	−12·5	26
	7	8 18 23·9	+0 56·93	−0 50·2	20·20	F	1 52 36·82	8·935	−50 25 19·3	9·429$_n$	−1·26	−12·3	27
	8	8 19 52·3	−0 8·11		10	F	1 54 38·69	8·940			−1·28	−12·3	28
		8 29 22·2		−6 58·0	·10	F			−50 49 31·0	9·479$_n$			28

1884.		Cape Mean Time.	Comet − ✱ Δα	Comet − ✱ Δδ	No. of Comp.	Obser-ver.	Comet's App. R.A.	Log. par. factor.	Comet's App. Dec.	Log. par. factor.	Reductions to Apparent Place.		Comp. Star.
		h m s	m s	′ ″			h m s				s	″	
Mar.	9	8 48 15·8	+1 20·05	−5 28·1	8 8	F	1 56 45·09	8·946	−51 13 24·4	9·530$_n$	−1·32	−12·2	29
	14	8 12 27·7	−1 6·38	−5 4 3	6·6	F	2 7 25·45	8·963	−53 7 3 5	9·421$_n$	−1·49	−12·2	30
	16	8 13 14·2	−3 18 81	−7 12·1	6·6	F	2 11 56·09	8·971	−53 51 12 7	9·432$_n$	−1·54	−12 5	31
	21	8 3 22·7	+2 30·54	+3 42·6	10·10	F	2 23 57·67	8·990	−55 38 45·5	9·393$_n$	−1·78	−11·7	32
	22	8 19 13·5	+1 9·00	−2 24·4	10·10	F	2 26 33·24	9·007	−56 0 15·0	9·460$_n$	−1·80	−11·8	33
	24	8 7 28·5	+0 32·02	+3 44·4	12·12	F	2 31 47·55	9·003	−56 42 5·1	9·419$_n$	−1·90	−11·8	34
	27	7 52 50 0	−1 12·45	−4 29·8	16·16	P	2 40 6·54	9·013	−57 44 31·2	9·336$_n$	−1·99	−12·1	35
	28	7 46 47·7	−1 59·46	+3 57·4	12 12	F	2 43 0·54	9·016	−58 4 59·2	9·298$_n$	−2·04	−12·2	36
Apr.	1	7 42 25·8	+0 43·08	−4 50·3	8·8	F	2 55 20·93	9·033	−59 27 12 3	9·270$_n$	−2·21	−12·1	37
	13	7 30 18·0	−0 49·55	+6 46·9	8·8	F	3 40 37·27	9·084	−63 26 15·6	9·012$_n$	−2·74	−14·1	38
	14	7 25 31·0	+1 12·20	+3 35·7	8·8	F	3 45 2·52	9·089	−63 45 18·6	8·984$_n$	−2·84	−13·4	39
	21	7 35 19·4	−1 58·03	+8 21·2	12·12	P	4 19 53·75	9·123	−65 51 52·1	8·903$_n$	−3·08	−16·0	40
	22	7 41 44·1	+0 38·77	−4 14·3	16·16	P	4 25 25·40	9·130	−66 8 46·8	8·968$_n$	−3·10	−16·0	41
	23	7 40 13·3	+1 34·79	−3 10·1	12·12	P	4 31 6·00	9·133	−66 25 4·4	8·903$_n$	−3·13	−16·3	42
	26	7 30 5·4		−1 13·1	·12	F			−67 11 23·7	8·309$_n$	−3·17	−17·6	43
		7 35 26·8	−0 28·28		15	F	4 48 54·50	9·143					43
	29	7 48 59·6		+7 33·4	·6	F			−67 53 14·8	8·690$_n$	−3·22	−19·1	44
		8 6 27·5	−1 50·15		10	F	5 8 12·54	9·164					44

Mean Places of Comparison Stars.

No. of Star.	Mag.	Mean R.A. 1884·0.	Mean Dec. 1884·0.	Authority for Star's Place.
		h m s	° ′ ″	
1		23 25 32·02	− 4 43 16·1	3 Meridian Obs. Cape, 1884 = Lalande 46057.
2	10	0 9 59·71	−17 41 26·5	Equat. diff. from * *a*.
a	8½	0 7 19·23	−17 49 49·0	3 Meridian Obs. Cape.
3	8½	0 15 0·42	−20 34 23·8	2 " "
4	8½	0 16 0·06	−23 17 4·6	A.Oe.$_r$ 139 + Gould 0^h·408.
5	5	0 24 34·58	−24 25 45·4	Stone 179, Gould 0^h·639.
6	10½	0 37 6·60	−28 57 35·4	2 Meridian Obs., Cape.
7	6	0 43 0·84	−29 7 37·7	Stone 319.
8	9	0 41 23·06	−30 59 28·5	2 Meridian Obs., Cape.
9	6½	0 48 29·19	−32 57 52·8	Stone 353.
10	9½	0 53 57·40	−33 43 49·2	3 Meridian Obs., Cape.
11	10	0 56 31·71	−35 21 14·0	Equat. diff. from Stone 429.
12	6	1 1 0·22	−36 16 52·9	Stone 431.
13	10½	1 4 30·35	−37 46 25·4	3 Meridian Obs., Cape.
14	10½	1 9 47·08	−39 52 38·8	Equat. difference from * *b*.
b	8	1 14 19·09	−39 58 26·9	2 Obs. Cape: Gould 1^h·362.
15	9½	1 17 2·69	−41 4 52·1	" Gould 1^h·429.
16	6½	1 18 27·58	−41 52 25·1	Stone 545.
17	6	1 21 51·24	−42 20 58·2	" 568.
18	3	1 23 19·70	−43 54 46·0	" 580.
19	8	1 28 55·09	−44 56 36·8	Gould 1^h·755.
20	9	1 31 47·16	−45 23 51·7	" 1^h·833.
21	9	1 35 10·72	−45 59 27·5	2 Meridian Obs., Cape.
22	8	1 36 46·41	−46 35 39·1	Equat. diff. from Stone 646.
23	9½	1 41 30·81	−47 31 34·3	1 Obs. Cape: Gould 1^h·1055.
24	5½	1 45 40·50	−48 23 37·1	Stone 732.
25	9½	1 43 50·89	−48 44 17·9	Equat. diff. from * *c*.
c	9	1 42 41·90	−48 48 13·2	1 Obs. Cape: Gould 1^h·1086.
26	9½	1 47 46·58	−49 11 33·8	" " 1^h·1233.
27	6½	1 51 41·15	−50 24 16·8	Stone 769: Gould 1^h·1331.

No. of Star.	Mag.	Mean R.A. 1884·0.	Mean Dec. 1884·0.	Authority for Star's Place.
		h m s	° ′ ″	
28	8½	1 54 48·08	−50 42 20·7	2 Obs. Cape: Gould 1^h·1437.
29	8½	1 55 26·36	−51 7 44·2	Gould 1^h·1466.
30	9	2 8 33·32	−53 1 47·0	2 Obs. Cape, 1884.
31	9	2 15 16·44	−53 43 48·1	1 Obs. Cape: Gould 2^h·394.
32	9½	2 21 28·91	−55 42 16·4	2 Obs. Cape, 1884.
33	10	2 25 26·04	−55 57 38·8	Equat. diff. from ∗ *d*.
d	9½	2 24 38·24	−55 54 4·5	1 Obs. Cape: Gould 2^h·651.
34	10	2 31 17·43	−56 45 37·8	Equat. diff. from ∗ *e*.
e	8½	2 29 43·19	−56 49 40·0	2 Obs. Cape, 1884.
35	9½	2 41 20·98	−57 39 49·3	,,
36	8	2 45 2·04	−58 8 44·4	Gould 2^h·1231.
37	8	2 54 40·06	−59 22 9·9	1 Obs. Cape: Gould 2^h·1483.
38	9½	3 41 29·56	−63 32 48·4	Equat. diff. from ∗ *f*.
f	9	3 44 36·47	−63 31 19·6	1 Obs. Cape: Gould 3^h·1347.
39	10½	3 43 53·16	−63 48 40·9	Equat. diff. from ∗ *g*.
g	9	3 41 28·06	−63 48 50·7	1 Obs. Cape: Gould 3^h·1243.
40	9	4 21 54·86	−65 59 57·3	,, ,, 4^h·711.
41	8	4 24 49·73	−66 4 16·5	,, ,, 4^h·823.
42	8½	4 29 34·34	−66 21 38·1	2 Obs. Cape, 1884.
43	10½	4 49 25·95	−67 9 53·0	Equat. diff. from ∗ *h*.
h	9	4 49 15·70	−67 1 36·8	2 Obs. Cape, 1884.
44	9	5 10 5·91	−68 0 29·1	,, ,,

Notes.

Jan. 16. Head very bright.

24. Tail faint and less than 2° in length; quite straight.

28. Observations interfered with by clouds.

29. No trace of a stellar nucleus could be seen.

Feb. 4. Stellar nucleus, surrounded by coma almost as bright.

6. Head much more diffused.

9. Poor definition. Comet's head very diffused; takes about 1^s to transit the wire.

15. Tail very faint. At 8^h 15^m mean time I can trace it in the finder to the bright star following, and about half as far again. It is narrow and straight; the bright star is just inside its southern edge.

25. A very faint tail visible in the finder; position-angle approximately 134°.

Feb. 26. Position angle of tail = 114°. Traces of another very faint tail could just be seen at position angle 153° ± (see figure).

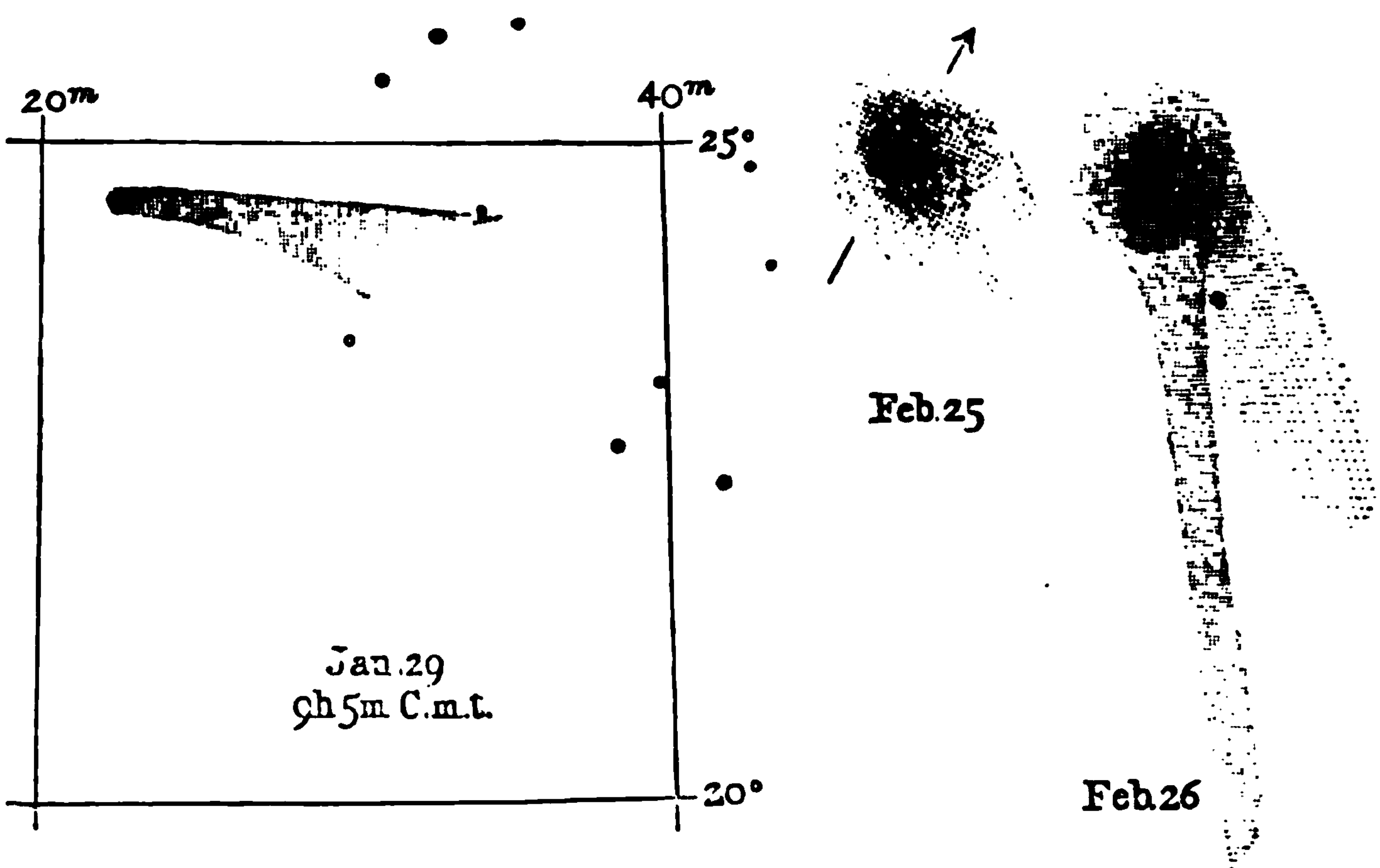
29. Definition poor, looking through vapour on the mountain. Comet a difficult object to bisect.

Mar. 2. Occasional glimpses of a star-like nucleus: the point observed was in following part of head (where the nucleus was seen).

21. Head bright, but ill-defined, surrounded by nebulous mass. Still faint trace of very short tail.

Apr. 13. An 11th magnitude star near the Comet very troublesome. The Comet was almost centrally over this star earlier in the evening, and the star then was brighter than when the Comet had passed away from it. The moonlight was, however, increasing rapidly towards the end of the measures.

21. Exceedingly faint.



Observations of Comet 1884 II. (Barnard), made at the Royal Observatory, Cape of Good Hope.

(*Communicated by David Gill, LL.D., F.R.S., H.M. Astronomer.*)

The following observations are in continuation of those given in vol. xlv. 1 :—

Date.		Cape Mean Time.	Comet−Star. Δα	Δ N.P.D.	No. of Comp.	Observer.	Comparison Star.
Oct.	14	9 53 42·7	−0 6·41	+4 38·1	32·16	F	*r* = AOe₂ 21151.
	15	9 45 49·0	−0 4·28	−2 33·9	24·16	F	*s*
	16	11 1 50·6	−0 17·32	−2 37·0	16·12	F	*t*
	17	9 56 51·5	+0 35·86	+3 42·1	24·16	F	*v*
	20	10 33 4·0	−0 1·70	−1 31·2	16·8	F	*w*
	24	10 26 26·6	−0 30·77	+0 49·1	6·14	F	*x*

Adopted Right Ascensions and North Polar Distances of Stars observed with the Comet.

Star.	Mag.	R.A. 1884·0.	N.P.D. 1884·0.	Reduct. to App. Place.		Authority for Star's Mean Place.
		h m s	° ′ ″	s	″	
r	8	21 2 16·77	109 11 40·2	+3·25	−19·6	3 Obs. Cape, 1884.
s	9	21 5 15·53	108 57 25·9	+3·24	−19·7	Equat. diff. from *s′*.
s′	8½	21 3 49·83	108 55 44·3	+3·24	−19·7	2 Obs. Cape(=AOe₂ 21180).
t	8½	21 8 37·75	108 34 59·4	+3·23	−19·9	4 Obs. Cape, 1884.
v	10	21 10 35·30	108 8 16·6	+3·22	−20·0	Equat. diff. from *v′*
v′	9	21 13 16·30	108 7 26·8	+3·23	−20·1	3 Obs. Cape, 1884.
w	8½	21 20 1·46	107 9 40·1	+3·20	−20·5	2 „ „
x	9½	21 31 49·03	105 44 28·4	+3·17	−21·0	Equat. diff. from *x′*.
x′	8	21 36 22·20	105 51 41·8	+3·19	−21·0	2 Obs. Cape, 1884.

Resulting Places of the Comet.

Date.	Cape Mean Time.	Right Ascension.	Log. par. factor.	North Polar Distance.	Log. par. factor.
	h m s	h m s		° ′ ″	
Oct. 14	9 53 42·7	21 2 13·61	8·545	109 15 58·7	9·484
15	9 45 49·0	21 5 14·49	8·526	108 54 32·3	9·484
16	11 1 50·6	21 8 23·66	8·676	108 32 2·5	9·571
17	9 56 51·5	21 11 14·38	8·556	108 11 38·7	9·511
20	10 33 4·0	21 20 2·96	8·618	107 7 48·4	9·556
24	10 26 26·6	21 31 21·43	8·627	105 44 56·5	9·587

Notes.

Oct. 15. Comet faint; difficult in R.A.
16. Comet *very* faint.
20, 24. Comet excessively faint.

Errata, Monthly Notices, vol. xlv. 1.

Page 46. In Δα for Sept. 21, *for* −0 16·20 *read* −0 16·70.
49. Aug. 14. *For* Cape Mean Time *read* 9ʰ 48ᵐ 55ˢ·4.
49. Sept. 21. *For* R.A. *read* 19ʰ 43ᵐ 24ˢ·52.

Observations of Comet 1884 (Wolf) made at the Royal Observatory, Cape of Good Hope.

(Communicated by D. Gill, LL.D., F.R.S., H.M. Astronomer).

1884.		Cape Mean Time.	Comet – ✱ Δα	Comet – ✱ Δδ	No. of Comp.	Obser-ver.	Comet α App.	Log. (p×Δ)	Comet δ App.	Log. (p×Δ)	Red. to App. Place.		Comp. Star No.
		h m s	m s	′ ″			h m s		° ′ ″		s	″	
Oct.	20	8 49 36·7	–0 32·94	+0 38·9	30·16	F	21 47 43·01	8·175	+8 11 1·0	9.822_n	+3·21	+28·8	1
	23	10 45 1·3	+0 51·91	+1 52·0	8·6	F	21 53 8·77	8·601	+6 45 53·0	9.793_n	+3·19	+28·4	2
	24	9 18 12·4	+0 19·88	+0 26·2	14·20	F	21 54 51·27	8·280	+6 20 58·5	9.803_n	+3·20	+28·2	3
	25	9 27 16·9	+0 35·23	+2 24·3	16·20	F	21 56 45·52	8·406	+5 54 38·6	9.798_n	+3·19	+28·1	4
Nov.	3	8 51 22·4	+0 38·90	+4 55·7	10·8	F	22 14 54·58	8·326	+2 17 27·1	9.767_n	+3·16	+26·8	5
	4	8 57 23·1	–0 31·73	–3 31·9	12·12	F	22 17 3·96	8·361	+1 55 14·9	9.763_n	+3·18	+26·7	6
	6	8 54 24·9	+0 35·08	+3 57·0	14·6	F	22 21 26·87	8·365	+1 12 45·0	9.757_n	+3·16	+26·3	7
	8	8 34 19·1	+0 12·69	+3 8·0	30·20	F	22 27 1·55	8·288	+0 34 2·0	9.750_n	+3·18	+26·0	8
	10	8 37 9·3	+0 46·56	–1 44·2	20·16	F	22 30 27·40	8·317	–0 6 24·8	9.743_n	+3·16	+25·7	9
	12	8 30 10·3	+0 21·98	–2 53·9	20·16	F		8·298		9.737_n	+3·15	+25·4	10
	17	8 30 4·2	–1 5·27	+3 15·9	16·12	F		8·336		9.722_n	+3·15	+24·4	11
	18	8 35 57·6	+0 51·86	–0 13·7	16·8	F	22 49 24·36	8·473	–2 21 1·2	9.721_n	+3·16	+24·3	12
	25	8 29 30·9	–1 29·69	+2 5·4	10·8	F		8·382		9.702_n	+3·16	+22·9	13
Dec.	9	8 56 6·8	+0 34·17	+6 46·1	20·16	F	23 42 32·76	8·527	–5 45 42·2	9.687_n	+3·15	+20·2	14
	15	8 42 30·5	+0 36·99	–3 17·9	20·16	F		8·515		9.682_n	+3·15	+19·0	15
1885. Jan.	7	8 55 24·5	–0 33·58	+1 8·1	8·12	F	0 57 2·05	8·609	–5 53 7·0	9.693_n	+0·16	– 5·2	16
	10	8 49 11·8	+0 43·91	–2 44·3	7·8	F	1 4 34·79	8·607	–5 41 26·9	9.695_n	+0·15	– 5·6	17

1885.	Cape Mean Time. h m s	Comet − ✱ Δα m s	Comet − ✱ Δδ ′ ″	No. of Comp. ″	Observer.	Comet α App. h m s	Log. $(p \times \Delta)$	Comet δ App. ° ′ ″	Log. $(p \times \Delta)$	Rel. to App. Place. s	Rel. to App. Place. ″	Comp. Star. No.
Jan. 12	9 1 2·7	−0 42·18	+0 52·3	12·12	F	1 9 37·64	8·632	−5 32 47·1	9·700$_n$	+0·16	−6·0	18
14	9 4 2·4	+0 59·92	+3 8·3	16·12	F	1 14 38·32	8·640	−5 23 31·9	9·703$_n$	+0·16	−6·3	19
15	8 53 51·8	−1 21·91	−3 40·9	8·12	F	1 17 7·19	8·627	−5 18 27·4	9·702$_n$	+0·18	−6·4	20
19	8 46 6·2	+0 19·39	+0 3·8	13·12	F	1 27 2·01	8·623	−4 57 23·9	9·704$_n$	+0·18	−6·9	21
20	8 54 30·0	−1 22·77	+1 39·4	12·14	F	1 29 31·77	8·638	−4 51 48·6	9·707$_n$	+0·20	−7·1	22
21	8 51 39·5	+0 35·00	−2 12·7	12·8	F	1 32 0·15	8·637	−4 46 9·1	9·708$_n$	+0·18	−7·2	23
Feb. 12	8 28 59·3	−0 47·51	+3 28·4	16·8	F	2 25 12·30	8·652	−2 19 22·4	9·728$_n$	+0·19	−9·8	24
13	8 34 11·3	+0 43·86	+3 53·2	16·12	F	2 27 35·16	8·660	−2 12 8·4	9·730$_n$	+0·20	−9·8	25
14	8 34 24·2	+0 27·67	+0 0·5	16·12	F	2 29 58·83	8·662	−2 4 54·4	9·731$_n$	+0·19	−9·9	26

The comet was also observed on the Meridian on two occasions:—

1884.	Cape Mean Time.	Δα	Δδ	No. of Comp.	Observer.	Comet α App.	Log. $(p \times \Delta)$	Comet δ App.	Log. $(p \times \Delta)$	Rel. to App. Place. s	Rel. to App. Place. ″	Comp. Star. No.
Oct. 24	7 40 32·4			6·1	F	21 54 45·98		+6 22 52·7	9·809$_n$			
25	7 38 27·9			6	F	21 56 37·66						

Notes.

Nov. 3. Comet very faint: moonlight and haze.
6. Measures frequently interrupted by cloud.
18. Only one comparison (through cloud) was obtained between stars 12 and *h*.

Dec. 9. Nucleus = star of 11th magnitude.
Jan. 10. Comet faint: hazy.
21. Comet very faint: moonlight: a very faint star near the comet was troublesome.

Errata.—W.B. xxii. 574. This star is Lalande 44096 and Glasgow 5876. The R.A. given in W.B. is about 20^s too great.
W.B. i. 122 and 126. The differences between these two stars, measured on Jan. 12, were 21^s·68 and 5′ 20″·0. The place of the second star given in W.B. requires a correction of −2′ in declination.
W.B. i. 183. Precession in R.A. *for* 3^s·018 *read* 3^s·028. W.B. i. 514. Precession in Dec. *for* 19″·59 *read* 18″·59.

Observations of Comet 1884 (Wolf) made at the Royal Observatory, Cape of Good Hope.

(Communicated by D. Gill, LL.D., F.R.S., H.M. Astronomer).

1884.	Cape Mean Time.	Comet – ✱ Δα	Comet – ✱ Δδ	No. of Comp.	Observer.	Comet α App.	Log. (p × Δ)	Comet δ App.	Log. (p × Δ)	Red. to App. Place.		Comp. Star No.
	h m s	m s	′ ″			h m s		° ′ ″		s	″	
Oct. 20	8 49 35·7	–0 32·94	+0 38·9	30·16	F	21 47 43·01	8·175	+8 11 1·0	9·822$_n$	+3·21	+28·8	1
23	10 45 1·3	+0 51·91	+1 52·0	8·6	F	21 53 8·77	8·601	+6 45 53·0	9·793$_n$	+3·19	+28·4	2
24	9 18 12·4	+0 19·88	+0 26·2	14·20	F	21 54 51·27	8·280	+6 20 58·5	9·803$_n$	+3·20	+28·2	3
25	9 27 16·9	+0 35·23	+2 24·3	16·20	F	21 56 45·52	8·406	+5 54 38·6	9·798$_n$	+3·19	+28·1	4
Nov. 3	8 51 22·4	+0 38·90	+4 55·7	10·8	F	22 14 54·58	8·326	+2 17 27·1	9·767$_n$	+3·16	+26·8	5
4	8 57 23·1	–0 31·73	–3 31·9	12·12	F	22 17 3·96	8·361	+1 55 14·9	9·763$_n$	+3·18	+26·7	6
6	8 54 24·9	+0 35·08	+3 57·0	14·6	F	22 21 26·87	8·365	+1 12 45·0	9·757$_n$	+3·16	+26·3	7
8	8 34 19·1	+0 12·69	+3 8·0	30·20	F	22 27 1·55	8·288	+0 34 2·0	9·750$_n$	+3·18	+26·0	8
10	8 37 9·3	+0 46·56	–1 44·2	20·16	F	22 30 27·40	8·317	–0 6 24·8	9·743$_n$	+3·16	+25·7	9
12	8 30 10·3	+0 21·98	–2 53·9	20·16	F		8·298		9·737$_n$	+3·15	+25·4	10
17	8 30 4·2	–1 5·27	+3 15·9	16·12	F		8·336		9·722$_n$	+3·15	+24·4	11
18	8 35 57·6	+0 51·86	–0 13·7	16·8	F	22 49 24·36	8·473	–2 21 1·2	9·721$_n$	+3·16	+24·3	12
25	8 29 30·9	–1 29·69	+2 5·4	10·8	F		8·382		9·702$_n$	+3·16	+22·9	13
Dec. 9	8 56 6·8	+0 34·17	+6 46·1	20·16	F	23 42 32·76	8·527	–5 45 42·2	9·687$_n$	+3·15	+20·2	14
15	8 42 30·5	+0 36·99	–3 17·9	20·16	F		8·515		9·682$_n$	+3·15	+19·0	15
1885. Jan. 7	8 55 24·5	–0 33·58	+1 8·1	8·12	F	0 57 2·05	8·609	–5 53 7·0	9·693$_n$	+0·16	– 5·2	16
10	8 49 11·8	+0 43·91	–2 44·3	7·8	F	1 4 34·79	8·607	–5 41 26·9	9·695$_n$	+0·15	– 5·6	17

1885.		Cape Mean Time.	Comet − ✱ Δα	Δδ	No. of Comp.	Observer.	Comet α App.	Log. (p×Δ)	Comet δ App.	Log. (p×Δ)	Red. to App. Place.		Comp. Star. No.
		h m s	m s	′ ″	″		h m s		° ′ ″		s	″	
Jan.	12	9 1 2·7	−0 42·18	+0 52·3	12·12	F	1 9 37·64	8·632	−5 32 47·1	9·700$_n$	+0·16	− 6·0	18
	14	9 4 2·4	+0 59·92	+3 8·3	16·12	F	1 14 38·32	8·640	−5 23 31·9	9·703$_n$	+0·16	− 6·3	19
	15	8 53 51·8	−1 21·91	−3 40·9	8·12	F	1 17 7·19	8·627	−5 18 27·4	9·702$_n$	+0·18	− 6·4	20
	19	8 46 6·2	+0 19·39	+0 3·8	13·12	F	1 27 2·01	8·623	−4 57 23·9	9·704$_n$	+0·18	− 6·9	21
	20	8 54 30·0	−1 22·77	+1 39·4	12·14	F	1 29 31·77	8·638	−4 51 48·6	9·707$_n$	+0·20	− 7·1	22
	21	8 51 39·5	+0 35·00	−2 12·7	12·8	F	1 32 0·15	8·637	−4 46 9·1	9·708$_n$	+0·18	− 7·2	23
Feb.	12	8 28 59·3	−0 47·51	+3 28·4	16·8	F	2 25 12·30	8·652	−2 19 22·4	9·728$_n$	+0·19	− 9·8	24
	13	8 34 11·3	+0 43·86	+3 53·2	16·12	F	2 27 35·16	8·660	−2 12 8·4	9·730$_n$	+0·20	− 9·8	25
	14	8 34 24·2	+0 27·67	+0 0·5	16·12	F	2 29 58·83	8·662	−2 4 54·4	9·731$_n$	+0·19	− 9·9	26

The comet was also observed on the Meridian on two occasions:—

1884.		Cape Mean Time.	No. of Comp.	Observer.	Comet α App.	Comet δ App.	Log. (p×Δ)
Oct.	24	7 40 32·4	6·1	F	21 54 45·98	+6 22 52·7	9·809$_n$
	25	7 38 27·9	6	F	21 56 37·66		

Notes.

Nov. 3. Comet very faint: moonlight and haze.
6. Measures frequently interrupted by cloud.
18. Only one comparison (through cloud) was obtained between stars 12 and *h*.

Dec. 9. Nucleus = star of 11th magnitude.
Jan. 10. Comet faint: hazy.
21. Comet very faint: moonlight: a very faint star near the comet was troublesome.

Errata.—W.B. xxii. 574. This star is Lalande 44096 and Glasgow 5876. The R.A. given in W.B. is about 20ˢ too great.

W.B. i. 122 and 126. The differences between these two stars, measured on Jan. 12, were 21ˢ·68 and 5′ 20″·0. The place of the second star given in W.B. requires a correction of −2′ in declination.

W.B. i. 183. Precession in R.A. *for* 3ˢ·018 *read* 3ˢ·028. W.B. i. 514. Precession in Dec. *for* 19″·59 *read* 18″·59.

Assumed Mean Places of Comparison Stars.

Comp. Star. No.	Mag.	α 1884·0. h m s	δ 1884·0. ° ′ ″	Authority.
1	9	21 48 12·74	+8 9 53·4	2 Obs. Cape (= W.B. xxi. 1095).
2	9½	21 52 13·67	+6 43 32·6	Equat. diff. from ∗ *a*.
a	9	21 50 43·10	+6 41 34·8	1 Obs. Cape (= W.B. xxi. 1150).
3	9	21 54 28·19	+6 20 4·1	Equat. diff. from ∗ *b*.
b	9½	21 55 6·36	+6 16 15·8	Equat. diff. from ∗ *c*.
c	6	21 54 20·29	+6 9 43·1	= 18 Pegasi ½(Gr. '64 + Yarn.)
4	9½	21 56 7·10	+5 51 46·3	Equat. diff. from ∗ *d*.
d	8½	21 54 57·47	+5 46 22 8	2 Obs. Cape
5	9	22 14 12·52	+2 12 4·6	2 Obs. Cape (= W.B. xxii. 247).
6	9½	22 17 32·51	+1 58 20·1	Equat. diff. from ∗ *e*.
e	9	22 18 54·64	+2 3 58·1	1 Obs. Cape (= W.B. xxii. 366).
7	9	22 20 48·63	+1 8 21·7	Equat. diff. from ∗ *f*.
f	8½	22 21 54·41	+1 3 57·9	1 Obs. Cape (= W.B. xxii. 437).
8		22 26 45·68	+0 30 28·0	*Astr. Nach.* No. 2644.
9	10½	22 29 37·68	−0 5 6·3	Equat. diff. from ∗ *g*.
g	8	22 28 39·98	−0 0 4·0	1 Obs. Cape (= W.B. xxii. 574).
10		22 34 41	−0 41	(= Arg. −0°·4399).
11	9½	22 48 (3)	−2 9	
12	10	22 48 (29·34)	−2 21 (11·8)	Equat. diff. from ∗ *h*.
h	9	22 47 12 04	−2 14 40·6	W.B. xxii. 953.
13	9	23 8 (28)	−3 53	
14	8	23 41 55·44	−5 52 48·5	W.B. xxiii. 821.
15	9	23 57 (44)	−6 4	
		1885·0.	1885·0.	
16	10½	0 57 35·47	−5 54 9·9	Equat. diff. from ∗ *i*.
i	8	0 58 47·95	−5 26 25·9	W.B. 0, 1003.
17	9	1 3 50·73	−5 38 37·0	W.B. i. 12.
18	8½	1 10 19·66	−5 33 33·4	W.B. i. 122.
19	9½	1 13 38·24	−5 26 33·9	Equat. diff. from ∗ *k*.
k	8½	1 13 43·30	−5 31 2·0	W.B. i. 183.
20	10½	1 18 28·92	−5 14 40·1	Equat. diff. from ∗ *l*.
l	8½	1 20 32·02	−5 16 7·5	W.B. i. 315.
21	10	1 26 42·44	−4 57 20·8	Equat. diff. from ∗ 22.
22	9	1 30 54·34	−4 53 20·9	W.B. i. 502.
23	8	1 31 24·97	−4 43 49·2	W.B. i. 514.
24	10	2 25 59 62	−2 22 41·0	Equat. diff. from ∗ 25.
25	9	2 26 51·10	−2 15 51·8	W.B. ii. 422.
26	10	2 29 30·97	−2 4 45·0	Equat. diff. from ∗ *m*.
m	9½	2 33 7·20	−2 4 56·9	W.B. ii. 537.

Observations of Comet 1885 . . . (Barnard) at Harrow with the $18\frac{1}{2}$*-inch Equatorial Reflector and Ring Micrometer.*
By G. L. Tupman.

	Green. Mean Time.	Δα	Δδ	No. of Comp.	☄ app. α	☄ app. δ	Log. fact. Parallax.		✱
	h m s	s	′ ″		h m s	° ′ ″			
1885, July 15	10 48 22·8	+ 2·55	− 7 54·3	6	17 7 25·18	− 9 16 31·6	+8·137	+9·938	1
	12 17 9·7	− 4·97	−10 4·4	22	17 7 17·66	− 9 18 41·7	+8·444	+9·928	1
July 17	10 35 49·1	+31·87	− 1 2·8	24	17 4 1·24	−10 23 14·1	+8·128	+9·942	2
	10 59 35·7	+29·93		6	17 3 59·30		+8·244		2

The comet was very faint, the sky being hazy on both nights; some 30″ or 40″ diameter, with central condensation admitting of pretty accurate observation. All the transits were registered on the chronograph. The apparent places of the comet differ slightly from those published in the *Ast. Nach.*, No. 2676, the places of the stars being derived from recent observations.

Mean Places of the Comparison Stars for 1885·0.

	h m s	s	° ′ ″	″	
1	17 7 19·68	+2·95	− 9 8 45·6	+8·3	Harrow Meridian Obs. 1885, 3, 3
2	17 3 26·42	+2·95	−10 22 19·4	+7·9	Greenwich Obs. 1883–84, 3, 3*

* By permission of the Astronomer Royal.

On the Proper Motions of the Stars LL. 31296 *and* 31188.
By G. L. Tupman.

LL. 31296. For this star we have the following observations reduced to 1885·0 by Peters' constants:—

	R.A. h m s	Decl. ° ′ ″	
1800	17 7 19·35	−9 8 45·5	LL. 31296
1825	19·86	47·5	W.B. 58,* 83
1850	19·60	44·7	Lam, 2078
1860	19·55	44·2	Yarnall 7133, 2 Obs.
1860	19·55	43·8	Schj. 6146

The star was observed three times on the Meridian at Harrow:—

	h m s	° ′ ″
	17 7 19·80	−9 8 44·8
	19·65	46·4
	19·59	45·6
1885·56	17 7 19·68	−9 8 45·6

The Annual Proper Motion appears to be quite insensible.

LL. 31188. For this star, reduced to 1885·0, we have:—

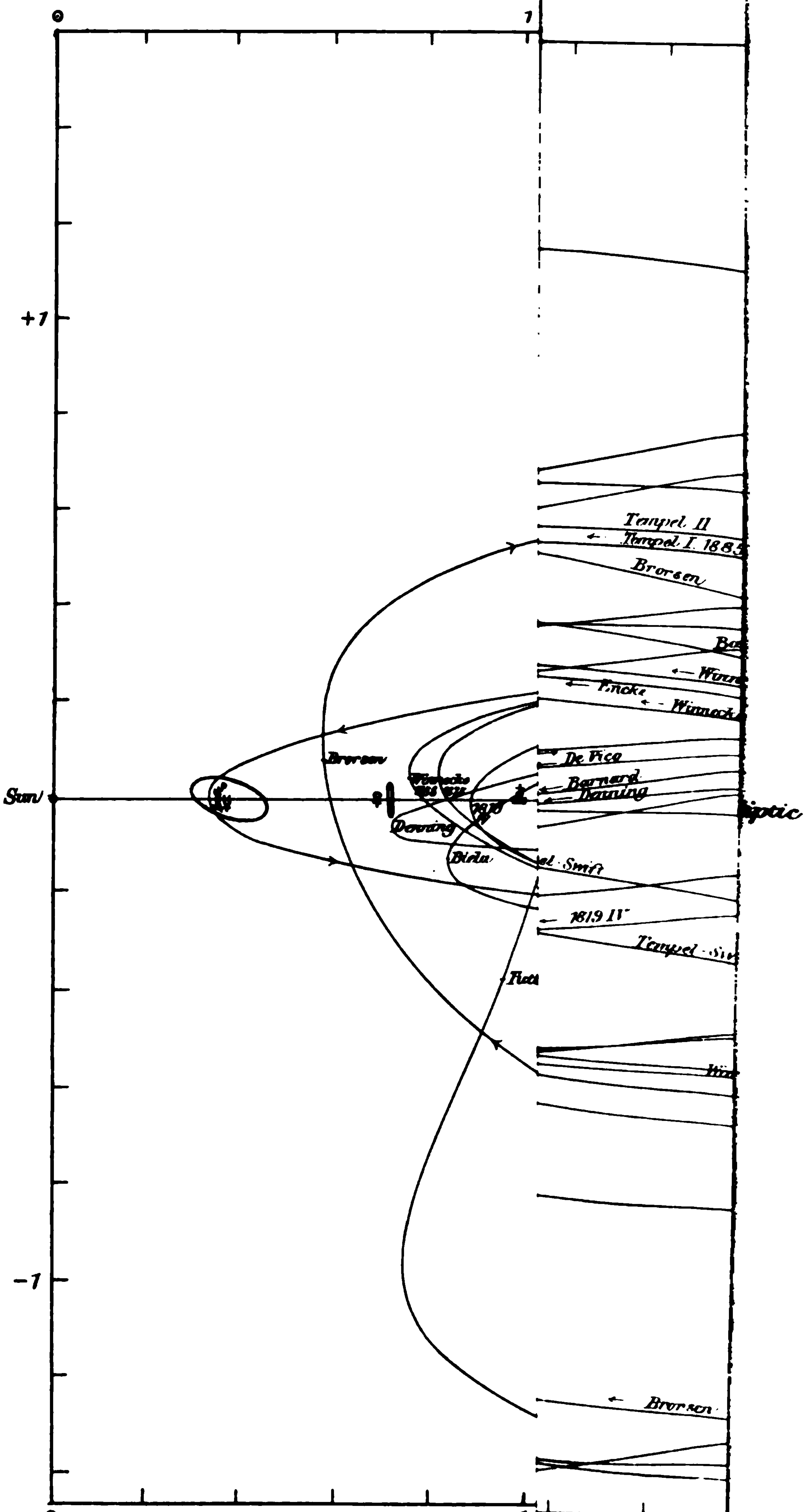
	R.A. h m s	Decl. ° ′ ″	
1800	17 3 26·21	−10 22 10·9	LL. 31188
1824	26·57	15·6	W.B.,1 3
1850	26·43	15·1	Lam, 2067
1850	26·25	16·0	Rad. Obs. 5, 2
1860	26·40	14·4	Sant. 1899, 2 Obs.
1884	26·42	19·4	Greenwich, 3 Obs.

By the method of least squares the Annual Proper Motion appears to be

in R.A. 0s·000 in Decl. −0″·108.

* WB_1, No. 58 is evidently another observation of No. 83. There is no star in the place of No. 58.

Monthly Notices of Royal Astronomical S



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etary orbits o

Data for a Graphical Representation of the Solar System. By A. Marth.

(*Continued from p.* 373.)

On account of the variety of the intersects of cometary orbits, and of the consequent inequalities in the number and distribution of the points, of which the co-ordinates are given, the succession of the groups of orbits cannot well be arranged in chronological order, but has to be made so as to keep orbits of similar type or of cognate character, as far as feasible, together. The order in which the following list is arranged will be easily recognised and appreciated by those who make practical use of it. The periodical comets of short or moderate periods are found in the first nine groups; group 10 contains the three principal comets moving in meteoric tracks, and then follow groups of comets of kindred type, beginning with those which approach nearest to the Sun, and ending with the comet of 1729. Though, in the case of those comets, the periodicity of which is determined from the observations of only one apparition, the uncertainty of the more distant parts of their tracks is considerable, it is of interest to learn something of their approaches to the orbits of the great planets, and the co-ordinates for these parts are therefore not omitted, it being understood that in some cases, as, for instance, in that of the Comet 1881 V., discovered by Denning, the portion extending beyond the orbit of *Jupiter* may be found, on the return of the comet, to require considerable corrections. Even in some well-determined orbits the data for the more distant parts are somewhat uncertain, simply because they are founded upon the published elements, which are valid only for the epoch for which they are given, and the changes of which cannot be taken into account as they are unpublished. The effect of these changes after a number of years may be seen in the case of Winnecke's and of Tempel's first periodical comet by laying down the intersects for the two revolutions, for which the data are contained in the list. As the changes of the orbit of Tempel's comet have been very remarkable, it will be of special interest to compare also the intersect of part of the orbit described at the comet's first appearance in 1867, and I give therefore the co-ordinates derived from Sandberg's elements (*Astr. Nachr.* 74, 103) :—

v	l	$r\cos b$	$r\sin b$	v	l	$r\cos b$	$r\sin b$
° −70	° 166·02	2·000	+0·203	° 0	° 236·34	1·559	+0·123
60	176·07	1·870	·203	+10	246·32	1·568	·101
50	186·13	1·767	·198	20	256·29	1·594	·075
40	196·19	1·687	·189	30	266·25	1·637	·047
30	206·25	1·628	·177	40	276·19	1·698	0·017
20	216·29	1·588	·162	50	286·13	1·778	−0·017
10	226·22	1·565	·144	60	296·07	1·880	·054
0	236·34	1·559	0·123	70	306·02	2·008	0·095

The changes in the intersect of Encke's comet are very moderate, as will be seen by comparison of a few of the co-ordinates of the orbit, which the comet described in 1819, with the corresponding one of 1885 given in the list:—

v	l	$r \cos b$	$r \sin b$	v	l	$r \cos b$	$r \sin b$
−180°	336°92	4·093	+0·041	0°	156°·92	0·335	−0·003
150	6·25	2·319	0·295	90	247·06	0·602	0·146
120	36·31	1·053	0·225	120	277·73	1·055	0·214
90	67·06	0·602	0·146	150	307·65	2·324	0·255

In the list of co-ordinates the designation of a comet and the name of its first discoverer (if the discovery was a telescopic one) in the first line is followed in the second line by the name of the computer, whose determination of the elements has been used, and by a statement of the epoch, to the ecliptic and equinox of which the co-ordinates are referred. The following are the sources from which the elements have been taken. Where no reference is given the elements are those of Galle's list in the third edition of Olbers's *Abhandlung*. The numbers in brackets [ ] indicate the group in the list of co-ordinates in which the comet is to be found. The twelve periodical comets, which have unquestionably been observed at different returns to perihelion, arranged in the order in which their periodicity was fully proved, are given first, and are then followed by the rest arranged in chronological order.

☞ Halley [8], *Astron. Nachr.*, 25, 189. Encke [1], *Bulletin astron.*, 1, 536. Biela [2], *A. N.*, 63, 297. Faye [3], *Berliner Astr. Jahrbuch* 1882, p. [138]. Brorsen [3]. *A. N.*, 95, 70. D'Arrest [3], *A. N.*, 105, 82. Tuttle [7], *Vierteljahrsschrift der Astr. Ges.*, 6, 100. Winnecke [2], *A. N.*, 97, 337. Tempel I. [4], *A. N.*, 95, 79, and *Nature*, 31, 468. Tempel II. [5], *A. N.*, 106, 221. Tempel-Swift [4], *Annuaire des Longitudes*, 1885, 218. Pons-Brooks [8], *A. N.*, 108, 16.

☞ 1770, I. [6], *A. N.*, 19, 165. 1783 [5], Galle. 1815 [8], *Vtjschrft. d. Astr. Ges.*, 17, 113. 1819, IV., *Berliner Astr. Jahrbuch*, 1824, 220. 1844, I. [6]. 1846, IV. [9]. 1846, VI. [7]. 1847, V. [9], *A. N.*, 28, 222. 1852, IV. [9], *A. N.*, 49, 356. 1861, I. [10], *A. N.*, 62, 187. 1862, III. [10], *A. N.*, 69, 87. 1866, I. [10], *A. N.*, 68, 249. 1867, I. [7], *A. N.*, 69, 111. 1881, V. [1], *A. N.*, 105, 111. 1884, II. [6], *A. N.*, 111, 15. 1884, III. [5], *A. N.*, 110, 207.

A copy of the intersect-data for the orbits of sixty-seven other comets, and of the outer planets *Saturn*, *Uranus*, and *Neptune*, is in the library of the Astronomical Society.

GROUP I.

	Encke's ☄.—1885. Backlund.—Eq. 85·0.			☄ 1819, IV., Blanpain. Encke.—Eq. 20·0.			☄ 1881, V., Denning. W. Plummer.—Eq. 81·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−180°	338°·45	4·096	+0·063	247°·43	4·804	+0·130	198°·81	7·805	+0·685
175	343·32	4·011	·139	252·37	4·766	·064	203·81	7·667	·616
170	348·21	3·776	·203				208·80	7·274	·526
165	353·10	3·443	·250	262·25	4·472	−0·062	213·79	6·701	·427
160	358·01	3·066	·279				218·77	6·040	·330
155	2·93	2·691	·292				223·75	5·366	·242
150	7·87	2·343	·294	277·08	3·710	·200	228·72	4·729	·167
145	12·83	2·037	·289				233·69	4·154	·105
140	17·82	1·773	·278				238·65	3·651	·055
135	22·82	1·550	·265	291·98	2·915	·264	243·62	3·219	·015
130	27·85	1·362	·250				248·58	2·850	−0·016
120	37·96	1·073	·220	306·96	2·276	·276	258·52	2·271	·060
110	48·15	0·868	·191	317·00	1·949	·267	268·46	1·854	·085
100	58·39	0·722	·164	327·08	1·691	·252	278·42	1·549	·100
90	68·65	0·616	·141	337·19	1·487	·233	288·40	1·324	·107
80	78·89	0·538	·119	347·31	1·328	·211	298·41	1·156	·110
70	89·09	0·480	·100	357·44	1·205	·188	308·44	1·029	·110
60	99·23	0·436	·082	7·54	1·108	·165	318·49	0·933	·107
45	114·27	0·391	·058	22·65	1·005	·130	333·59	0·851	·100
30	129·12	0·363	·036	37·66	0·939	·095	348·69	0·768	·090
15	143·82	0·347	+0·015	52·58	0·903	·060	3·77	0·733	·078
0	158·45	0·342	−0·005	67·43	0·892	−0·024	18·81	0·723	·063
+15	173·10	0·348	·025	82·25	0·905	+0·013	33·79	0·736	·047
30	187·87	0·362	·045	97·08	0·943	·051	48·72	0·772	·027
45	202·82	0·390	·067	111·98	1·009	·091	63·62	0·837	·004
60	217·96	0·435	·089	126·96	1·113	·135	78·52	0·939	+0·025
70	228·15	0·479	·105	137·00	1·208	·166	88·46	1·034	·048
80	238·39	0·537	·122	147·08	1·330	·198	98·42	1·159	·075
90	248·65	0·616	·141	157·19	1·487	·233	108·40	1·324	0·107
100	258·89	0·723	·160	167·31	1·688	·268	118·41	1·546	·147
110	269·09	0·870	·181	177·44	1·944	·304	128·44	1·845	·196
120	279·23	1·076	·203	187·54	2·268	·338	138·49	2·257	·258
130	289·28	1·367	·223				148·55	2·830	·33
+135	294·27	1·555	−0·231	202·65	2·903	+0·376	153·59	3·196	+0·383

GROUP 1—*continued.*

	Encke's ☄.—1885. Backlund.—Eq. 85·0.			☄ 1819, IV., Blanpain. Encke.—Eq. 20·0.			☄ 1881, V., Denning. W. Plummer.—Eq. 81·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
+ 140°	299°·24	1·779	−0·236	°			158°·62	3·626	+0·434
145	304·19	2·043	·237				163·66	4·127	·490
150	309·12	2·350	·232	217·66	3·696	+0·374	168·69	4·699	·550
155	314·03	2·706	·217				173·72	5·337	·609
160	318·93	3·073	·190				178·75	6·013	·664
165	323·82	3·452	·148	232·58	4·462	·295	183·77	6·678	·708
170	328·70	3·781	·089				188·79	7·257	·731
175	333·57	4·013	·017	242·49	4·762	·192	193·80	7·658	·724
+ 180	348·45	4·096	+0·063	247·43	4·804	+0·130	198·81	7·805	+0·685

GROUP 2.

	Biela's ☄—1852. Santini.—Eq. 52·74.			1858, Eq. 58·0— Winnecke's ☄. Oppolzer.			1875. Eq. 80·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
− 180°	288°·45	6·121	+0·922	95°·95	5·495	−0·317	96°·97	5·565	−0·280
175	293·45	6·037	0·992	100·87	5·436	·227	101·89	5·509	·185
170	298·47	5·821	1·030	105·79	5·257	·135	106·79	5·340	·089
165	303·51	5·502	1·035	110·70	4·981	−0·047	111·70	5·077	+0·002
160	308·58	5·115	1·012	115·61	4·642	+0·032	116·60	4·752	·083
155	313·66	4·697	0·968	120·52	4·271	·099	121·51	4·392	·151
150	318·75	4·277	·910	125·44	3·894	·153	126·42	4·023	·206
145	323·86	3·874	·844	130·36	3·530	·195	131·34	3·664	·247
140	328·97	3·502	·774	135·29	3·192	·226	136·27	3·327	·277
135	334·10	3·165	·705	140·23	2·884	·247	141·22	3·017	·298
130	339·22	2·866	·637	145·19	2·608	·261	146·17	2·738	·310
125	344·34	2·602	·573	150·16	2·365	·269	151·15	2·490	·317
120	349·45	2·371	·513	155·14	2·150	·272	156·14	2·270	·318
110	359·65	1·994	·406	165·15	1·799	·269	166·17	1·908	·310
100	9·78	1·708	·316	175·22	1·531	·257	176·27	1·630	·294
90	19·83	1·490	·239	185·35	1·328	·241	186·42	1·417	·273
80	29·80	1·322	·173	195·51	1·172	·221	196·60	1·254	·249
70	39·69	1·193	·117	205·69	1·054	·201	206·80	1·129	·224
60	49·52	1·093	·069	215·86	0·963	·180	216·98	1·034	·199
− 50	59·30	1·015	+0·026	226·01	0·895	+0·158	227·13	0·962	+0·173

GROUP 2—*continued.*

	Biela's ☄.—1852. Santini.—Eq. 52·74.			1858, Eq. 58·0.— Winnecke's ☄. Oppolzer.			1875. Eq. 80·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−40°	69°·06	0·955	−0·012	236°·11	0·844	+0·136	237°·23	0·909	+0·147
30	78·83	0·911	·045	246·16	0·808	·113	247·26	0·871	·121
20	88·64	0·879	·076	256·14	0·784	·091	257·22	0·845	·095
10	98·50	0·859	·103	266·07	0·771	·068	267·12	0·832	·069
0	108·45	0·850	·128	275·95	0·768	·044	276·97	0·828	·042
+10	118·47	0·852	·151	285·79	0·774	·020	286·79	0·834	·014
20	128·58	0·865	·171	295·61	0·789	−0·005	296·60	0·851	−0·015
30	138·75	0·892	·190	305·44	0·815	·032	306·42	0·878	·045
40	148·97	0·933	·206	315·29	0·853	·060	316·27	0·917	·077
50	159·22	0·991	·220	325·19	0·904	·091	326·17	0·971	·110
60	169·45	1·070	·232	335·14	0·972	·123	336·14	1·043	·146
70	179·65	1·175	·239	345·15	1·061	·159	346·17	1·136	·185
80	189·78	1·311	·242	355·22	1·177	·198	356·27	1·258	·227
90	199·83	1·490	·239	5·35	1·328	−0·241	6·42	1·417	·273
100	209·80	1·722	·226	15·51	1·526	·288	16·60	1·625	·323
110	219·69	2·025	·199	25·69	1·787	·341	26·80	1·896	·377
120	229·52	2·421	·152	35·86	2·131	·397	36·98	2·251	·433
125	234·41	2·662	·118	40·94	2·341	·426	42·06	2·467	·461
130	239·30	2·935	·075	46·01	2·581	·455	47·13	2·712	·488
135	244·18	3·243	·021	51·07	2·854	·483	52·19	2·988	·513
140	249·06	3·586	+0·044	56·11	3·159	·508	57·23	3·295	·534
145	253·94	3·963	·124	61·14	3·496	·528	62·25	3·631	·549
150	258·83	4·367	·218	66·16	3·859	·542	67·26	3·990	·556
155	263·73	4·785	·327	71·16	4·237	·545	72·25	4·360	·551
160	268·64	5·195	·448	76·14	4·611	·534	77·22	4·723	·532
165	273·56	5·568	·576	81·11	4·956	·507	82·18	5·053	·495
170	278·50	5·869	·705	86·07	5·238	·461	87·12	5·322	·439
175	283·46	6·062	·823	91·01	5·426	·396	92·05	5·500	·366
+180	288·45	6·121	+0·922	95·95	5·495	−0·317	96·97	5·565	−0·280

GROUP 3.

	Brorsen's ☄.—1879. Schulze, cor. by Harzer.—Eq. 79·0.			D'Arrest's ☄.—1877. Leveau.—Eq. 80·0.			Faye's ☄.—1881. Möller.—Eq. 80·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−180°	294°39	5·568	−0·709	140°80	5·747	−0·190	230°43	5·955	+0·424
175	298·85	5·446	0·923	144·24	5·728	·054	236·37	5·920	·516
170	303·36	5·158	1·090	149·05	5·620	+0·080	240·31	5·847	·598
165	307·95	4·753	1·199	153·87	5·448	·206	245·27	5·694	·665
160	312·63	4·287	1·254	158·69	5·223	·319	250·25	5·515	·720
155	317·42	3·808	1·263	163·53	4·961	·417	255·25	5·305	·760
150	322·31	3·353	1·238	168·39	4·677	·498	260·26	5·072	·786
145	327·32	2·939	1·190	173·27	4·383	·562	265·29	4·827	·799
140	332·45	2·575	1·129	178·17	4·088	·610	270·33	4·577	·800
135	337·71	2·262	1·060	183·11	3·804	·644	275·39	4·329	·791
130	342·98	1·995	0·989	188·07	3·535	·665	280·46	4·088	·774
125	348·56	1·769	·919	193·07	3·284	·675	285·55	3·858	·750
120	354·14	1·580	·850	198·11	3·053	·677	290·64	3·641	·720
115	359·79	1·421	·784	203·17	2·842	·671	295·73	3·438	·687
110	5·50	1·288	·721	208·27	2·651	·660	300·83	3·250	·651
100	16·96	1·084	·607	218·54	2·326	·624	311·03	2·920	·573
90	28·32	0·940	·506	228·90	2·067	·577	321·19	2·647	·493
80	39·39	0·838	·416	239·28	1·863	·523	331·31	2·423	·413
70	50·02	0·765	·336	249·65	1·704	·466	341·37	2·242	·335
60	60·17	0·713	·264	259·96	1·581	·407	351·36	2·096	·260
50	69·85	0·674	·198	270·17	1·489	·347	1·28	1·981	·188
40	79·13	0·644	·137	280·26	1·420	·287	11·15	1·892	·120
30	88·11	0·622	·080	290·21	1·371	·227	20·98	1·824	·055
20	96·89	0·606	·026	300·04	1·339	·166	30·79	1·776	−0·007
10	105·61	0·593	+0·025	309·77	1·322	·105	40·60	1·745	·067
0	114·39	0·585	·075	320·80	1·314	·043	50·43	1·734	·124
+ 10	123·36	0·581	·123	329·05	1·326	−0·019	60·31	1·737	·178
20	132·63	0·582	·170	338·69	1·347	·082	70·25	1·761	·230
30	142·31	0·589	·217	348·39	1·382	·147	80·26	1·803	·279
40	152·45	0·603	·264	358·17	1·433	·214	90·33	1·867	·326
50	162·98	0·629	·312	8·07	1·502	·283	100·46	1·955	·370
60	174·14	0·669	·360	18·11	1·594	·353	110·64	2·072	·410
+ 70	185·50	0·729	+0·409	28·27	1·714	−0·426	120·83	2·223	−0·445

GROUP 3—*continued.*

	Brorsen's ☄.—1879. Schulze, cor. by Harzer.—Eq. 79·0.			D'Arrest's ☄.—1877. Leveau.—Eq. 80·0.			Faye's ☄.—1881. Möller.—Eq. 80·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
+80°	196°·96	0·817	+0·457	38°·54	1·869	−0·501	131°·03	2·412	−0·474
90	208·32	0·940	·506	48·90	2·067	·577	141·19	2·647	·493
100	219·39	1·113	·553	59·28	2·318	·652	151·31	2·934	·500
110	230·02	1·352	·594	69·65	2·635	·721	161·37	3·279	·490
115	235·17	1·504	·611	74·81	2·822	·753	166·37	3·473	·476
120	240·17	1·682	·623	79·96	3·028	·780	171·36	3·683	·457
125	245·07	1·892	·630	85·08	3·256	·802	176·33	3·906	·429
130	249·85	2·136	·628	90·17	3·503	·817	181·28	4·142	·393
135	254·45	2·421	·614	95·23	3·770	·824	186·22	4·387	·349
140	259·13	2·750	·585	100·26	4·046	·819	191·15	4·637	·294
145	263·65	3·126	·534	105·24	4·345	·801	196·07	4·887	·229
150	268·11	3·545	·456	110·21	4·640	·767	200·98	5·131	·154
155	272·52	3·998	·345	115·14	4·949	·715	205·88	5·358	·069
160	276·89	4·462	·194	120·04	5·193	·643	210·79	5·562	+0·023
165	281·25	4·902	·003	124·91	5·423	·553	215·69	5·731	·122
170	285·61	5·267	−0·222	129·77	5·603	·445	220·60	5·874	·225
175	289·99	5·504	·467	134·60	5·719	·322	225·51	5·934	·326
+180	294·39	5·568	−0·709	140·80	5·747	−0·190	230·43	5·955	+0·424

GROUP 4.

	☄ Tempel–Swift, 1880. Schulhof & Bossert.—Eq. 80·0.			1879. Eq. 79·0.	☄ Tempel I. Gautier.		1885. —Eq. 85·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−180°	223°·15	5·103	−0·462	58°·47	4·812	−0·288	61°·63	4·894	−0·176
175	228·16	5·068	·445	63·41	4·800	·219	66·54	4·884	·097
170	233·18	4·962	·419	68·34	4·756	·148	71·45	4·847	·016
165	238·19	4·797	·386	73·27	4·683	·077	76·36	4·786	+0·062
160	243·20	4·584	·348	78·20	4·583	·008	81·28	4·702	·138
155	248·20	4·338	·307	83·13	4·460	+0·058	86·19	4·599	·209
150	253·21	4·075	·265	88·06	4·320	·120	91·12	4·479	·274
140	263·19	3·542	·185	97·93	4·005	·227	101·00	4·207	·385
130	273·17	3·049	·115	107·83	3·673	·307	110·93	3·911	·466
−120	283·14	2·626	−0·059	117·78	3 349	+0·363	120·92	3·616	+0·518

GROUP 4—*continued.*

	Temple-Swift, 1880. Schulhof & Bossert.—Eq. 80·0.			1879, Eq. 79·0.			Tempel I. Gautier.	1885. —Eq. 85·0.	
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
° −110	° 293·09	2·276	−0·014	° 127·78	3·050	+0·397	° 130·98	3·338	+0·545
100	303·05	1·993	+0·020	137·82	2·785	·412	141·09	3·085	·550
90	313·01	1·766	·046	147·91	2·556	·412	151·24	2·863	·538
80	322·98	1·584	·066	158·04	2·362	·400	161·41	2·673	·512
70	332·96	1·441	·080	168·18	2·202	·379	171·59	2·514	·475
60	342·95	1·327	·090	178·33	2·072	·352	181·75	2·384	·431
50	352·96	1·239	·097	188·46	1·969	·319	191·83	2·280	·380
40	2·98	1·172	·101	198·55	1·890	·283	201·94	2·199	·325
30	13·02	1·122	·103	208·60	1·832	·242	211·94	2·140	·266
20	23·06	1·088	·102	218·60	1·793	·199	221·89	2·100	·205
10	33·10	1·069	·100	228·56	1·771	·154	231·78	2·078	·141
0	43·15	1·063	·096	238·47	1·766	·106	241·63	2·072	·075
+ 10	53·18	1·070	·090	248·34	1·777	·055	251·45	2·082	·007
20	63·20	1·090	·083	258·20	1·804	·003	261·28	2·109	−0·062
30	73·21	1·124	·073	268·06	1·847	−0·051	271·12	2·152	·132
40	83·19	1·174	·061	277·93	1·908	·108	281·00	2·214	·203
50	93·17	1·242	·047	287·83	1·988	·166	290·93	2·295	·273
60	103·14	1·330	·030	297·78	2·090	·227	300·92	2·398	·344
70	113·09	1·443	·009	307·78	2·216	·288	310·98	2·525	·412
80	123·05	1·586	−0·016	317·82	2·370	·350	321·09	2·680	·478
90	133·01	1·766	·046	327·91	2·556	·412	331·24	2·863	·538
100	142·98	1·991	·083	338·04	2·776	·470	341·41	3·078	·589
110	152·96	2·273	·126	348·18	3·031	·522	351·59	3·323	·628
120	162·95	2·621	·178	358·33	3·321	·564	1·75	3·595	·650
130	172·96	3·042	·238	8·46	3·638	·590	11·83	3·885	·648
140	182·98	3·533	·304	18·55	3·968	·593	21·94	4·179	·618
150	193·02	4·067	·372	28·60	4·284	·567	31·94	4·454	·554
155	198·04	4·330	·403	33·61	4·427	·541	36·92	4·575	·509
160	203·06	4·577	·430	38·60	4·555	·506	41·89	4·682	·456
165	208·08	4·791	·451	43·59	4·660	·463	46·84	4·770	·395
170	213·10	4·958	·464	48·56	4·741	·411	51·78	4·836	·327
175	218·13	5·066	·468	53·52	4·792	·352	56·71	4·878	·254
+180	223·15	5·103	−0·462	58·47	4·812	−0·288	61·63	4·894	−0·176

Group 5.

	Tempel II., 1883. Schulhof.—Eq. 80·0.			1783, Pigott. Peters.—Eq. 1783·0.			1884, III., Wolf. Krüger.—Eq. 84·0.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
−180°	125°99	4·665	+0·091	231°87	5·051	+0·337	199°75	5·564	−0·303
175	130·87	4·640	·179	235·40	5·038	0·024			
170	135·76	4·572	·263	238·94	4·961	−0·283	208·80	5·466	+0·109
165	140·66	4·464	·339	242·49	4·823	0·575			
160	145·57	4·323	·406	246·10	4·635	0·842	217·88	5·153	0·485
155	150·50	4·156	·463	249·79	4·407	1·079			
150	155·45	3·971	·508	253·59	4·150	1·282	227·08	4·696	0·783
140	165·40	3·575	·566	261·65	3·596	1·581	236·50	4·179	0·989
130	175·44	3·184	·586	270·52	3·047	1·748	246·20	3·667	1·108
120	185·57	2·826	·578	280·49	2·555	1·808	256·25	3·204	1·155
110	195·76	2·515	·549	291·76	2·146	1·788	266·64	2·807	1·150
100	205·99	2·253	·508	304·37	1·830	1·712	277·35	2·481	1·106
90	216·25	2·037	·459	318·07	1·606	1·598	288·29	2·222	1·038
80	226·48	1·861	·406	332·20	1·464	1·460	299·34	2·022	0·952
70	236·67	1·720	·351	345·96	1·387	1·306	310·34	1·871	0·857
60	246·79	1·609	·296	358·67	1·358	1·143	321·17	1·761	0·754
50	256·83	1·522	·240	10·04	1·357	0·975	331·72	1·683	0·647
40	266·80	1·455	·185	20·10	1·375	0·803	341·93	1·629	0·538
30	276·66	1·406	·131	29·05	1·397	0·629	351·79	1·595	0·427
20	286·46	1·372	·078	37·16	1·421	0·453	1·33	1·576	0·315
10	296·24	1·352	·026	44·69	1·441	0·276	10·62	1·568	0·201
0	305·99	1·344	−0·026	51·87	1·456	0·097	19·75	1·570	0·085
+10	315·76	1·350	·078	58·94	1·465	+0·084	28·80	1·580	−0·032
20	325·57	1·368	·129	66·10	1·467	0·267	37·88	1·600	0·150
30	335·45	1·401	·179	73·59	1·464	0·452	47·08	1·629	0·272
40	345·40	1·449	·229	81·65	1·457	0·641	56·50	1·670	0·395
50	355·44	1·515	·279	90·52	1·450	0·832	66·20	1·726	0·521
60	5·57	1·603	·328	100·49	1·449	1·025	76·25	1·802	0·650
70	15·76	1·715	·375	111·76	1·464	1·220	86·64	1·904	0·780
80	25·99	1·858	·419	124·37	1·510	1·412	97·35	2·041	0·910
90	36·25	2·037	·459	138·07	1·606	1·598	108·29	2·222	1·038
100	46·48	2·256	·492	152·20	1·815	1·770	119·34	2·457	1·157
110	56·67	2·522	·515	165·96	2·033	1·915	130·34	2·758	1·262
+120	66·79	2·837	−0·521	178·67	2·394	+2·016	141·17	3·131	−1·341

Group 5—*continued.*

	Tempel II., 1883. Schulhof.—Eq. 80·0.			1783, Pigott. Peters.—Eq. 1783·0.			1884, III., Wolf. Krüger.—Eq. 84·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
+130°	76°·83	3·198	−0·505	190°·04	2·854	+2·048	151°·72	3·576	−1·376
140	86·80	3·591	·457	200·10	3·392	1·981	161·93	4·077	1·347
150	96·66	3·986	·372	209·05	3·961	1·782	171·79	4·599	1·231
155	101·57	4·170	·315	213·20	4·236	1·626			
160	106·46	4·335	·247	217·16	4·489	1·431	181·33	5·075	1·013
165	111·36	4·474	·170	220·98	4·707	1·199			
170	116·24	4·579	·087	224·69	4·880	0·934	190·60	5·423	0·694
175	121·12	4·644	+0·001	228·31	4·997	0·644			
+180	125·99	4·665	+0·091	231·87	5·051	+0·337	199·75	5·564	−0·303

Group 6.

	1770, I. Clausen.—Eq. 1770·75.			1844, I., De Vico. Brünnow.—Eq. 1844·66.			1884. II., Barnard. Berberich.—Eq. 84·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−180°	176°·28	5·631	+0·108	162°·52	5·008	+0·252	126°·29	4·832	+0·395
175	181·28	5·553	·116	167·53	4·978	·246	131·30	4·809	·371
170	186·28	5·333	·119	172·54	4·889	·236	136·31	4·736	·341
165	191·28	5·004	·118	177·54	4·748	·221	141·31	4·618	·306
160	196·28	4·609	·114	182·54	4·565	·204	146·30	4·464	·268
155	201·28	4·188	·108	187·55	4·352	·184	151·30	4·282	·228
150	206·28	3·773	·100	192·55	4·120	·164	156·29	4·081	·188
145	211·28	3·382	·091	197·55	3·379	·143	161·27	3·869	·150
140	216·29	3·027	·083	202·55	3·638	·122	166·26	3·654	·113
135	221·29	2·711	·075	207·55	3·404	·102	171·24	3·441	·079
130	226·29	2·434	·067	212·55	3·180	·084	176·22	3·236	·048
120	236·29	1·984	·053	222·54	2·775	·051	186·17	2·856	−0·005
110	246·30	1·647	·041	232·53	2·432	·024	196·13	2·528	·046
100	256·30	1·395	·032	242·51	2·149	·002	206·09	2·251	·077
90	266·30	1·204	·024	252·50	1·919	−0·015	216·06	2·022	·099
80	276·30	1·060	·017	262·49	1·733	·028	226·05	1·835	·115
70	286·30	0·949	·011	272·48	1·584	·039	236·05	1·684	·125
60	296·29	0·865	·006	282·48	1·465	·047	246·07	1·562	·130
45	311·29	0·774	·000	297·48	1·335	·055	261·12	1·428	·132
−30	326·28	0·717	−0·005	312·49	1·249	−0·059	276·18	1·340	−0·128

GROUP 6—*continued.*

	☄ 1770, I. Clausen.—Eq. 1770·75.			☄ 1844, I., De Vico. Brünnow.—Eq. 1844·66.			☄ 1884, II., Barnard. Berberich.—Eq. 84·0		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−15°	341°·28	0·685	−0·009	327°·51	1·200	−0·061	291°·25	1·290	−0·118
0	356·28	0·674	·013	342·52	1·185	·060	306·29	1·275	·104
+15	11·28	0·685	·016	357·54	1·201	·056	321·31	1·293	·086
30	26·28	0·716	·019	12·55	1·249	·050	336·29	1·344	·062
45	41·29	0·774	·021	27·55	1·335	·040	351·24	1·434	·033
60	56·29	0·864	·023	42·54	1·466	·027	6·17	1·568	+0·003
70	66·30	0·949	·024	52·53	1·584	·016	16·13	1·688	·031
80	76·30	1·060	·024	62·51	1·733	·002	26·09	1·837	·063
90	86·30	1·204	·024	72·50	1·919	+0·015	36·06	2·022	+0·099
100	96·30	1·395	·022	82·49	2·149	·035	46·05	2·248	·140
110	106·30	1·648	·020	92·48	2·432	·059	56·05	2·521	·187
120	116·29	1·985	·015	102·48	2·774	·088	66·07	2·846	·237
130	126·29	2·435	·007	112·48	3·179	·121	76·10	3·223	·291
135	131·29	2·712	·001	117·48	3·402	·139	81·12	3·427	·317
140	136·29	3·028	+0·006	122·48	3·637	·158	86·14	3·639	·343
145	141·28	3·383	·015	127·48	3·878	·177	91·16	3·854	·367
150	146·28	3·774	·026	132·49	4·119	·195	96·18	4·067	·388
155	151·28	4·189	·038	137·49	4·351	·213	101·20	4·269	·405
160	156·28	4·610	·052	142·50	4·564	·228	106·23	4·453	·417
165	161·28	5·005	·067	147·51	4·747	·240	111·25	4·609	·423
170	166·28	5·334	·083	152·51	4·888	·249	116·26	4·729	·421
175	171·28	5·554	·097	157·52	4·978	·253	121·28	4·805	·412
+180	176·28	5·631	+0·108	162·52	5·008	+0·252	126·29	4·832	+0·395

GROUP 7.

	☄ Tuttle.—1858. Tischler.—Eq. 58·0.			☄ 1846, VI., Peters. Peters.—Eq. 46·0.			☄ 1867, I., Coggia. Searle.—Eq. 67·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−180°	285°·43	9·717	+3·829	62°·74	9·295	+1·663	256°·01	19·261	+0·286
175	288·89	9·275	4·398	67·16	9·266	1·254	260·76	18·858	−0·234
170	292·91	8·527	4·756	71·53	9·048	0·827	265·51	17·732	0·702
165	296·54	7·590	4·895	75·86	8·667	0·410	270·27	16·129	1·074
160	300·84	6·588	4·849	80·17	8·168	0·026	275·05	14·321	1·335
155	305·54	5·617	4·667	84·49	7·593	−0·311			
−150	310·70	4·739	+4·400	88·82	6·985	−0·594	284·69	10·871	−1·573

GROUP 7—*continued.*

	Tuttle.—1858. Tischler.—Eq. 58·0.			1846, VI., Peters. Peters.—Eq. 46·0.			1867, I., Coggia. Searle.—Eq. 67·0.		
v	l	r cos b	r sin b	l	r cos b	r sin b	l	r cos b	r sin b
°	°			°			°		
−145	316·40	3·979	+4·089	93·18	6·379	−0·823			
140	322·68	3·345	3·763	97·59	5·795	1·000	294·46	8·167	−1·574
135	329·59	2·828	3·441	102·07	5·250	1·133			
130	337·10	2·417	3·132	106·63	4·750	1·228	304·40	6·230	1·504
125	345·14	2·095	2·842	111·28	4·298	1·291			
120	353·56	1·850	2·573	116·03	3·895	1·329	314·52	4·875	1·328
115	2·14	1·666	2·325	120·91	3·538	1·346			
110	11·63	1·532	2·097	125·91	3·223	1·347	324·80	3·924	1·181
100	26·47	1·367	1·696	136·30	2·706	1·314	335·22	3·272	1·047
90	40·00	1·285	1·356	147·20	2·316	1·249	345·73	2·762	0·908
80	51·17	1·241	1·064	158·52	2·028	1·164	356·25	2·409	0·786
70	60·39	1·211	0·812	170·07	1·820	1·068	6·72	2·151	0·672
60	68·20	1·186	0·590	181·63	1·676	0·965	17·09	1·961	0·567
50	75·04	1·158	0·392	192·96	1·580	0·857	27·30	1·822	0·468
40	81·28	1·127	0·213	203·90	1·522	0·746	37·34	1·722	0·374
30	87·19	1·090	0·050	214·33	1·491	0·631	47·20	1·651	0·283
20	93·02	1·049	−0·101	224·24	1·482	0·514	56·90	1·605	0·195
10	99·02	1·004	0·243	233·68	1·487	0·394	66·49	1·580	0·109
0	105·43	0·954	0·376	242·74	1·505	0·269	76·01	1·572	0·023
+10	112·91	0·902	0·503	251·53	1·532	0·140	85·51	1·582	+0·063
20	120·84	0·849	0·625	260·17	1·568	−0·005	95·05	1·610	0·150
30	130·70	0·800	0·743	268·82	1·614	+0·137	104·69	1·658	0·240
40	142·68	0·762	0·857	277·59	1·670	0·288	114·46	1·730	0·333
50	157·10	0·747	0·968	286·63	1·740	0·450	124·40	1·831	0·432
60	172·56	0·773	1·075	296·03	1·830	0·624	134·52	1·969	0·537
70	191·63	0·860	1·177	305·91	1·947	0·814	144·80	2·158	0·649
80	206·47	1·026	1·273	316·30	2·104	1·021	155·22	2·413	0·772
90	220·00	1·285	1·356	327·20	2·316	1·249	165·73	2·762	0·908
100	231·17	1·653	1·418	338·52	2·609	1·498	176·25	3·266	1·065
110	240·39	2·158	1·446	350·07	3·013	1·768	186·72	3·911	1·223
115	244·44	2·472	1·439	355·86	3·268	1·910			
120	248·20	2·837	1·411	1·63	3·567	2·054	197·09	4·854	1·403
125	251·72	3·260	1·357						
130	255·04	3·747	1·267	12·96	4·313	+2·339	207·30	6·200	+1·592
+135	258·22	4·308	−1·131						

GROUP 7—*continued.*

	☄ Tuttle.—1858. Tischler.—Eq. 58·0.			☄ 1846, VI., Peters. Peters.—Eq. 46·0.			☄ 1867, I., Coggia, Searle.—Eq. 67·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
°	°			°			°		
+140	261·28	4·948	−0·935	23·90	5·281	+2·587	217·34	8·317	+1·763
145	264·26	5·667	0·662						
150	267·19	6·460	0·294	34·33	6·457	2·733	227·20	10·827	1·856
155	270·10	7·300	+0·186						
160	273·02	8·141	0·787	44·24	7·716	2·677	236·90	14·278	1·706
165	275·98	8·905	1·502				241·71	16·091	1·538
170	279·02	9·490	2·295	53·68	8·783	2·324	246·49	17·704	1·222
175	282·15	9·786	3·100				251·25	18·842	0·792
+180	285·43	9·717	+3·829	62·74	9·295	+1·663	256·01	19·261	+0·286

GROUP 8.

	Halley's ☄.—1835. Westphalen.—Eq. 1835·87.			Pons-Brooks's ☄.—1884. Schulhof & Bossert.—Eq. 80·0.			☄ 1815, Olbers, 1886. Ginzel.—Eq. 87·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
°	°			°			°		
−180	123·59	33·918	−10·097	259·56	31·97	+10·65	321·67	25·70	−21·26
175	118·42	30·575	8·740	261·14	28·66	12·26			
170	113·29	23·540	6·399	262·83	22·51	11·95	334·30	19·86	18·35
165	108·19	17·050	4·361	264·67	16·46	10·56			
160	103·14	12·344	2·935	266·73	11·741	8·980	347·92	13·19	12·91
155	98·13	9·148	1·996	269·06	8·370	7·558			
150	93·16	6·980	1·376	271·76	6·014	6·381	1·92	8·54	8·34
145	88·23	5·477	0·957	274·96	4·361	5·430			
140	83·35	4·407	0·666	278·85	3·186	4·665	15·51	5·941	5·463
135	78·49	3·623	0·459	283·71	2·339	4·042	21·95	5·103	4·460
130	73·67	3·036	0·308	289·98	1·722	3·530	28·07	4·458	3·659
125	68·87	2·585	0·196	298·25	1·274	3·103	33·87	3·954	3·011
120	64·09	2·232	0·111	309·31	0·954	2·741	39·33	3·553	2·482
110	54·56	1·725	+0·006	341·15	0·620	2·165	49·33	2·957	1·678
100	45·02	1·385	0·078	14·57	0·572	1·726	58·25	2·534	1·105
90	35·43	1·147	0·124	35·79	0·635	1·377	66·37	2·216	0·680
80	25·74	0·976	0·154	47·89	0·707	1·092	73·93	1·963	0·356
70	14·91	0·849	0·176	55·46	0·762	0·852	81·10	1·756	0·101
60	5·90	0·756	0·183	60·74	0·799	0·645	88·30	1·579	+0·102
45	350·59	0·658	0·190	66·52	0·822	0·379	99·28	1·356	0·340
30	334·98	0·599	0·189	71·09	0·816	0·150	111·28	1·171	0·520
−15	319·25	0·568	+0·181	75·25	0·787	−0·055	125·15	1·028	+0·659

GROUP 8—*continued.*

	Halley's ☄.—1835. Westphalen.—Eq. 1835·87.			Pons-Brooks's ☄.—1884. Schulhof & Bossert.—Eq. 80·0.			☄ 1815. Olbers. 1886. Ginzel.—Eq. 87·0.		
	l	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
− 0°	303°·59	0·562	+ 0·167	79°·56	0·736	− 0·245	141°·67	0·925	+ 0·765
+ 15	288·19	0·578	0·148	84·67	0·664	0·426	161·02	0·882	0·844
30	273·16	0·616	0·121	91·76	0·569	0·604	181·92	0·918	0·897
45	258·49	0·680	0·086	103·71	0·453	0·784	201·95	1·053	0·920
60	244·09	0·777	0·039	129·31	0·337	0·969	219·33	1·300	0·906
70	234·56	0·867	− 0·003	161·15	0·315	1·099	229·33	1·529	0·868
80	225·02	0·986	0·056	194·57	0·410	1·235	238·25	1·829	0·797
90	215·43	1·147	0·124	215·79	0·635	1·377	246·37	2·216	0·680
100	205·74	1·370	0·216	227·89	0·988	1·526	253·93	2·720	0·493
110	194·91	1·689	0·349	235·46	1·502	1·678	261·10	3·394	0·196
120	185·90	2·172	0·527	240·74	2·258	1·823	268·30	4·325	− 0·280
125	180·84	2·509	0·653	242·88	2·773	1·887	271·90	4·930	0·623
130	175·74	2·942	0·811	244·79	3·418	1·934	275·55	5·668	1·067
135	170·59	3·509	1·014	246·52	4·241	1·955	279·28	6·573	1·649
140	165·42	4·268	1·282	248·13	5·310	1·930	283·13	7·700	2·419
145	160·21	5·312	1·642	249·65	6·722	1·825			
150	154·98	6·785	2·140	251·09	8·625	1·581	291·28	10·91	4·84
155	149·74	8·920	2·847	252·50	11·224	1·098			
160	144·49	12·084	3·368	253·87	14·780	0·201	300·27	16·00	9·20
165	139·25	16·769	5·340	255·25	19·509	+ 1·374			
170	134·01	23·274	7·310	256·64	25·181	3·913	310·33	22·09	15·60
175	128·78	30·398	9·336	258·08	30·30	7·35			
+ 180	123·59	33·918	− 10·097	259·56	31·97	+ 10·65	321·67	25·70	− 21·26

GROUP 9.

	☄ 1846, IV., De Vico. Peirce.—Eq. 46·0.			☄ 1847, V., Brorsen. D'Arrest.—Eq. 47·0.			1852, IV., Westphal. Möller.—Eq. 52·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
− 180°	258°·68	33·63	− 7·67	270°·84	34·26	− 7·49	215°·57	24·57	− 16·17
175	259·14	29·94	9·63						
170	259·62	22·92	9·64						
165	260·14	16·33	8·61	285·45	15·725	2·252	232·99	16·63	13·25
160	260·72	11·43	7·36	290·25	11·104	1·290	239·27	13·49	11·18
155	261·36	8·052	6·232	295·03	8·085	0·716	245·72	10·89	9·28
150	262·09	5·742	5·300	299·78	6·090	0·368	252·29	8·868	7·670
145	262·95	4·142	4·546	304·51	4·731	0·152	258·90	7·323	6·338
140	264·00	3·008	3·937	309·24	3·774	0·013	265·49	6·150	5·258
− 135	265·31	2·186	− 3·440	313·96	3·080	+ 0·077	271·96	5·255	− 4·383

GROUP 9—*continued.*

	☄ 1846, IV., De Vico. Peirce.—Eq. 46·0.			☄ 1847, V., Brorsen. D'Arrest.—Eq. 47·0.			1852, IV., Westphal. Möller.—Eq. 52·0.		
φ	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
−130°	267°·03	1·577	−3·028	318°·69	2·564	+0·137	278°·28	4·566	−3·665
125	269·43	1·118	2·683	323·44	2·169	0·177	284·38	4·028	3·076
120	273·06	0·766	2·390	328·26	1·862	0·204	290·23	3·603	2·587
110	291·97	0·291	1·919	337·83	1·423	0·232	301·15	2·981	1·827
100	18·23	0·155	1·556	347·61	1·133	0·241	311·06	2·554	1·273
90	47·11	0·310	1·265	357·58	0·932	0·240	320·08	2·241	0·854
80	66·13	0·443	1·024	7·75	0·790	0·232	328·44	2·000	0·528
70	70·04	0·537	0·820	18·11	0·687	0·222	336·32	1·805	0·267
60	72·31	0·601	0·642	28·60	0·613	0·209	343·95	1·643	0·055
45	74·49	0·657	0·410	44·46	0·539	0·186	355·35	1·440	+0·199
30	76·05	0·679	0·208	60·25	0·497	0·162	7·28	1·275	0·398
15	77·38	0·675	0·025	75·74	0·478	0·134	20·47	1·142	0·558
0	78·68	0·647	+0·148	90·84	0·477	0·104	35·57	1·044	0·687
+15	80·14	0·597	0·315	105·45	0·491	0·070	52·99	0·994	0·792
30	82·09	0·522	0·482	119·78	0·521	0·032	72·29	1·011	0·874
45	85·31	0·416	0·654	133·96	0·570	−0·014	91·96	1·117	0·932
60	93·06	0·268	0·837	148·20	0·644	0·070	110·23	1·335	0·959
70	111·97	0·147	0·969	157·83	0·713	0·116	121·15	1·556	0·954
80	198·23	0·111	1·110	167·61	0·805	0·171	131·06	1·851	0·923
90	227·11	0·310	1·265	177·58	0·932	0·240	140·08	2·241	0·854
100	246·30	0·621	1·435	187·75	1·111	0·327	148·44	2·759	0·728
110	250·04	1·064	1·624	198·11	1·372	0·443	156·32	3·459	0·512
115	251·30	1·357	1·726	—	—	—	160·16	3·904	0·354
120	252·31	1·716	1·832	208·60	1·773	0·604	163·95	4·432	0·149
125	253·15	2·163	1·942	213·88	2·057	0·710	167·73	5·067	−0·120
130	253·86	2·729	2·052	219·17	2·425	0·842	171·52	5·836	0·472
135	254·49	3·457	2·158	224·46	2·912	1·007	175·35	6·777	0·937
140	255·06	4·415	2·249	229·74	3·571	1·221	179·23	7·940	1·556
145	255·57	5·702	2·306	235·01	4·488	1·503	183·20	9·387	2·383
150	256·05	7·471	2·290	240·25	5·802	1·887	187·28	11·190	3·495
155	256·51	9·958	2·127	245·45	7·746	2·424	191·51	13·42	4·98
160	256·95	13·494	1·675	250·62	10·712	3·193	195·89	16·09	6·91
165	257·38	18·451	0·675	255·74	15·29	4·30	200·47	19·10	9·33
167·5	257·59	21·505	−0·149						
170	257·81	24·837	1·253						
175	258·24	31·15	4·31						
+180	258·68	33·63	−7·67	270·84	34·26	−7·49	215·57	24·57	−16·17

Group 10.

The three chief comets in the tracks of known meteor-swarms.

	1861, I. (*Lyrids*). Oppolzer.—Eq. 61·0.			1862, III. (*Perseids*). Oppolzer.—Eq. 62·0.			1866, I. (*Leonids*). Oppolzer.—Eq. 66·0.		
v	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$	l	$r \cos b$	$r \sin b$
−180	36°·62	92·79	+59·88	149°·09	43·66	−20·18	240°·06	19·652	−0·918
175							235·29	18·981	0·397
170	39·49	42·72	39·25	144·53	33·74	9·52	230·51	17·175	+0·086
165				142·51	25·723	5·096	225·74	14·827	0·459
160	43·41	14·41	19·03	140·36	19·292	2·243	220·95	12·453	0·706
155				138·35	14·593	0·523	216·16	10·336	0·849
150	49·51	5·84	10·84	136·35	11·227	+0·496	211·40	8·570	0·918
145				134·33	8·793	1·097	206·50	7·142	0·938
140	60·80	2·647	7·520	132·28	7·001	1·447	201·63	6·001	0·929
135	70·92	1·592	5·780	130·16	5·652	1·646	196·72	5·092	0·903
130	87·03	1·044	4·854	127·93	4·615	1·750	191·78	4·366	0·868
125	111·21	0·753	4·121	125·57	3·803	1·795	186·80	3·781	0·828
120	138·60	0·673	3·529	123·02	3·154	1·802	181·77	3·308	0·785
115	159·77	0·716	3·042	120·24	2·630	1·784	176·71	2·921	0·743
110	173·28	0·797	2·634	117·16	2·201	1·749	171·61	2·603	0·700
105	181·86	0·878	2·287	113·68	1·845	1·705	166·47	2·339	0·660
100	187·63	0·947	1·988	109·71	1·549	1·653	161·30	2·119	0·621
90	194·86	1·042	1·500	99·62	1·094	1·538	150·89	1·779	0·547
80	199·29	1·091	1·115	85·27	0·782	1·416	140·42	1·535	0·478
70	202·42	1·107	0·801	65·08	0·591	1·292	129·96	1·359	0·415
60	204·85	1·099	0·539	40·58	0·513	1·167	119·57	1·230	0·354
50	206·90	1·074	0·314	17·93	0·523	1·043	109·28	1·137	0·300
40	208·76	1·025	0·116	1·08	0·581	0·919	99·15	1·071	0·247
30	210·54	0·984	−0·058	349·31	0·656	0·794	89·18	1·024	0·195
20	212·36	0·924	0·217	340·84	0·734	0·668	79·36	0·995	0·145
10	214·34	0·854	0·363	334·34	0·807	0·538	69·66	0·979	0·095
0	216·62	0·774	0·499	329·09	0·874	0·404	60·06	0·975	0·046
+10	219·49	0·683	0·628	324·53	0·933	0·263	50·51	0·984	−0·005
20	223·41	0·568	0·750	320·36	0·985	0·115	40·95	1·004	0·057
30	229·51	0·468	0·868	316·35	1·029	−0·045	31·40	1·037	0·111
40	240·80	0·342	0·973	312·28	1·065	0·220	21·63	1·086	0·168
50	267·03	0·235	1·094	307·93	1·091	0·414	11·78	1·154	0·229
+60	318·60	0·229	−1·203	303·02	1·107	−0·632	1·77	1·246	−0·296

GROUP 10—*continued.*

	1861, I. (*Lyrids*). Oppolzer.—Eq. 61·0.			1862, III. (*Perseids*). Oppolzer.—Eq. 62·0.			1866, I. (*Leonids*). Oppolzer.—Eq. 66·0.		
v	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
	°			°			°		
+70	353·28	0·396	−1·308	297·16	1·112	−0·884	351·61	1·372	−0·369
80	7·63	0·671	1·408	289·71	1·106	1·180	341·30	1·543	0·452
90	14·86	1·042	1·500	279·62	1·094	1·538	330·89	1·779	0·547
100	19·29	1·541	1·574	265·27	1·095	1·983	320·42	2·108	0·657
105	20·97	1·856	1·599	255·93	1·117	2·250	315·19	2·321	0·719
110	22·42	2·229	1·613	245·08	1·170	2·556	309·96	2·578	0·787
115	23·70	2·679	1·610	233·04	1·276	2·911	304·75	2·888	0·862
120	24·85	3·226	1·581	220·58	1·461	3·326	299·57	3·266	0·944
125	25·91	3·906	1·515				294·41	3·730	1·035
130	26·90	4·765	1·393	197·93	2·212	4·412	289·28	4·304	1·135
135	27·85	5·878	1·182				284·20	5·020	1·245
140	28·76	7·921	0·896	181·08	3·821	6·043	279·15	5·918	1·364
145	29·65	9·391	0·252				274·14	7·047	1·489
150	30·54	12·293	+0·727	169·31	7·160	8·662	269·18	8·466	1·614
155	31·44	16·626	2·427				264·25	10·226	1·726
160	32·36	23·439	5·507	160·84	14·37	13·07	259·36	12·341	1·800
165							254·50	14·725	1·797
170	34·34	53·39	22·71	154·34	29·17	19·45	249·66	17·094	1·665
175							244·86	18·501	1·369
+180	36·62	92·79	+59·88	149·09	43·66	−20·18	240·06	19·652	−0·918

The graphical construction of a few intersects of cometary orbits on properly prepared paper, on which the intersects of the major planets are also laid down, will show to reflecting readers how much information may be got from these intersects even by mere inspection, and how much more may be derived with comparatively little trouble. The chief peculiarities of the orbits in reference to the Sun and to the plane of the ecliptic are directly exhibited in the intersects, and, though in order to learn what the corresponding longitudes are the lists of coördinates have to be consulted, approximate information respecting also the longitudes may be got at sight, if the portions of the intersects within the different sextants or quadrants of ecliptical longitude are inked in with inks of different colours, or are distinguished in some other way. With the help of an ordinary semicircular protractor, which is held perpendicular to the paper, with its centre coinciding with the zero of the co-ordinates or with the place of the Sun, and so as to represent the plane of

the ecliptic, it will be easy to form correct notions of the relative positions of a comet and of the Earth, when their heliocentric positions are given or are assumed. For, as the heliocentric place, l, x, z, of the comet is represented by the point x, z of its intersect on condition that the plane of the intersect is supposed to be in the heliocentric longitude l, the position of the Earth L, R, o, will be referred to this plane by making the radius vector R form the angle $l-L$ with the plane of the paper. Thus the position of the comet as seen from different points of the Earth's orbit may be readily recognised in reference to its heliocentric position, and the consideration of the circumstances of the comet's geocentric apparition under various conditions will give comparatively little trouble, as readers who make actual trial will find out for themselves.

The explanations which are required refer to the determinations of the proximities of the orbits. The intersects of the major planets being comparatively of small extent, while those of cometary orbits are large, the vicinity of the point of the cometary orbit, where it approaches nearest to the planetary orbit, will be readily recognised by inspection of the intersects, some regard being paid that the ecliptical longitudes should approximately correspond. To find the points of the true proximity, recourse must be had to the lists of co-ordinates and to proper computation.

Let l_0, x_0, z_0 denote the co-ordinates of a point of the cometary, l, x, z those of a point of the planetary orbit. The linear distance Δ between the two points is found by

$$\Delta^2 = 4xx_0 \sin^2 \tfrac{1}{2}(l-l_0) + (x-x_0)^2 + (z-z_0)^2.$$

The differentiation of this equation furnishes the equation of condition for determining the longitude l of that point of the planetary orbit which is nearest to the point l_0, x_0, z_0,

$$0 = xx_0 \sin(l-l_0) + (x - x_0 \cos(l-l_0))\frac{dx}{dl} + (z-z_0)\frac{dz}{dl},$$

an equation which can only be solved by successive approximations, as the values of x, z, and of the differential coefficients

$$\frac{dx}{dl} \text{ and } \frac{dz}{dl}$$

must correspond to the value of l, which is to be determined. By putting

$$\frac{dx}{xdl} = \tan\mu,$$

the equation for the determination of l becomes

$$0 = \sin(l-\mu-l_0) + \frac{x}{x_0} . \sin\mu + \frac{z-z_0}{x_0} . \frac{dz}{xdl} . \cos\mu,$$

the solution of which would be most readily effected, if the list of co-ordinates of the planetary orbit contained additional columns furnishing the values of

$$\mu, \sin\mu \text{ and of } \frac{dz}{xdl}\cos\mu = \nu,$$

determined by means of the equations

$$\tan\mu = \frac{dx}{xdl} = \frac{re\sin v}{p\cos i} - z \cdot \frac{\tan i}{p}(\cos u + e\cos\omega)$$

and

$$\nu = \frac{dz}{xdl}\cdot\cos\mu = x\cdot\frac{\tan i}{p}(\cos u + e\cos\omega)\cos\mu,$$

in which p denotes the semiparameter of the orbit and $u = \omega + v$ the argument of latitude or the departure from the node.

But in practice it may perhaps be considered sufficiently accurate to find the differential-coefficients from the differences of the published values of x and z, and to use the equation for the determination of l in the form

$$-\sin(l - l_0) = \frac{x - x_0}{x_0}\cdot\frac{dx}{xdl} + \frac{z - z_0}{x_0}\cdot\frac{dz}{xdl} + 2\sin^2\tfrac{1}{2}(l - l_0)\cdot\frac{dx}{xdl}$$

in which the last term is to be disregarded in the first approximation.

With the determination of the true value of l the point of the planetary orbit is found which is nearest to the point l_0, x_0, z_0 of the cometary orbit, which was assumed to be near the point of proximity. By repeating the determination for suitably altered values of l_0, and by comparing the resulting values Δ of the shortest distances, that value of l_0 is found which gives the minimum of the shortest distances and therewith the points of the closest proximity between the orbits.

This general method of solving the problem is only recommended in case one of the orbits is that of a major planet, and when the solution is wanted regardless of what the amount of the proximity may be. The determination of the proximities of the orbits of minor planets and of comets between themselves does not appear to have any practical interest, except in the cases of close proximities, when the orbits approach within, say, 0·01, or, at most, 0·02 of linear distance. Whether two orbits can approach within that limit is easily settled with the help of their intersects and the intersect data. Close proximities can only occur if the intersects cross or at least very nearly touch one another. In order that at the crossing points the two orbits should be within the assigned limits of distance 0·01 or 0·02, the ecliptical longitudes of the crossing points in the two orbits must not differ by more than $\frac{0^\circ\!\cdot\!573}{x}$ or $\frac{1^\circ\!\cdot\!146}{x}$, and,

where the intersects are merely close together, the difference between the longitudes must be still less. A reference to the intersect-data and a look at the longitudes of the points in question will decide at once whether there is the usual disagreement of the longitudes, or whether they agree near enough to require closer examination. In the latter case the computation of Δ for a few points in the neighbourhood will lead to the recognition of the true proximity. In the rare and exceptional cases of very close approaches it will, of course, be worth while to recompute the intersect-data for these points with greater accuracy, so as to insure that degree of correctness which may be considered desirable.

The application of this method for finding any close proximities between two orbits to the solution of the problem of finding all close proximities between any special orbit and all the other orbits is obvious. If the number of orbits which are to be considered is large, their intersects cannot be laid down on one sheet without overcrowding, but have to be judiciously spread over a series of sheets in collections of perhaps twenty or thirty intersects, so assorted as to permit clear discrimination. The search for close proximities between any special orbit and all the others may then be accomplished by means of a piece of tracing paper, on which the intersect of the special orbit is drawn, and which is to be placed in its correct position on each sheet.

The task of constructing the intersects graphically (on properly prepared paper, and with the intersect-data ready at hand) is a pleasant and instructive one, and the search for close proximities offers no difficulties and is interesting. The only drawback is, that it demands leisure, and that, if it is to be extended to many special orbits, the search cannot be indulged in but by those who can afford the time to undertake it. Except for this drawback, the solution of the problem of finding all close proximities between all fairly determined orbits of planets and comets would be within comparatively easy reach by applying the method generally. For though, when hundreds of orbits are to be considered, their mutual combinations may be counted by myriads, all those combinations, in which the intersects do not cross or touch, disappear at once from consideration as being obviously barren of proximities; the barrenness of a very large proportion of combinations will be easily recognised by a comparatively slight search; and only a moderate proportion of combinations will demand closer examination in order to discover the few hundred cases which will require strict investigation.

A special case of the problem of close proximities between two orbits is that in which one of the orbits is supplanted by a given straight line. The problem offers itself in astronomical practice in investigations concerning the possible identity of some periodical comet with one of the lost comets, which have

been observed only once or twice, and the orbit of which is unknown. The question whether at the time of the observation any point of the orbit of the periodical comet can have appeared in the observed place of the heavens will be most readily settled with the help of the two intersects, that of the orbit of the periodical comet and that of the straight line between the Earth and the lost comet. The following are the intersect-data for three of the lost comets:—the comet observed by Olbers, 1817, November 1 (*v. Berliner Astr. Jahrbuch*, 1817, p. 143); that observed by Hind, 1846, October 18 (*A. N.* 25, 206), and the object seen by Brorsen, 1854, March 16 (*A. N.* 38, 141). The argument Δ of the data is the geocentric distance of some point in the direction of the comet.

	☄ 1817, Nov. 1.			☄ 1846, Oct. 18.			? ☄ 1854, March 16.		
Δ	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*	*l*	*r* cos *b*	*r* sin *b*
0·0	39°·01	0·992	0·000	25·44	0·995	0·000	175°·90	0·996	0·000
0·1	36·09	·923	+0·053	28·62	·914	+0·024	172·03	·923	−0·022
0·2	32·70	·856	·105	32·40	·836	·047	167·52	·855	·045
0·3	28·76	·793	·158	36·97	·762	·071	162·28	·793	·067
0·4	24·15	·734	·211	42·45	·695	·095	156·20	·739	·089
0·5	18·79	·681	·264	49·04	·635	·119	149·26	·694	·112
0·6	12·58	·634	·316	56·88	·585	·142	141·50	·661	·134
0·7	5·48	·596	·369	65·98	·547	·166	133·10	·641	·157
0·8	357·57	·569	·422	76·11	·526	·190	124·36	·636	·179
0·9	349·03	·553	·474	86·75	·521	·213	115·68	·646	·201
1·0	340·20	0·550	+0·527	97·20	0·535	+0·237	107·43	0·669	−0·224

If the intersects of these and the other lost comets are laid down on a piece of tracing paper and placed upon the intersect of the periodical comet, the comparison of the ecliptical longitudes of the intersects at the crossing points will show whether there is any case requiring closer examination. In making the comparison, due allowance must be made not only for precession but also for the possible shifting of the intersect of the periodical comet in the interval.

It will scarcely be necessary to point to the great usefulness of the intersects of the orbits of planets and comets in some other investigations. I hope to extend the lists of intersect-data so as to comprehend all well-determined orbits and postpone some further remarks till then.

Colonel Cooper's Observatory:
Markree, Collooney, Ireland.

Ephemeris for Physical Observations

Greenwich Noon.		Angle of Position of ♃'s Axis.	Latitude of Earth above ♃'s Equator.	Latitude of Sun above ♃'s Equator.	Annual Parallax.		Longitude of ♃'s Central Meridian. (878°·40)	Longitude of ♃'s Central Meridian. (870°·31)	Corr. for Phase.
		P	B	*B*	A−L.	L−O.	I	II	
1885.		°	°	°	°	°	°	°	°
Nov.	14	25·431	−1·992	−1·811	−8·305	44·459	154·20	355·48	+0·300
	19	·415	2·035	1·828	8·744	45·278	225·71	26·54	·333
	24	·396	2·077	1·844	9·140	46·054	297·29	57·66	·364
	29	·374	2·119	1·860	9·490	46·782	8·92	88·84	·392
Dec.	4	25·350	−2·160	−1·876	−9·789	47·461	80·62	120·08	−0·417
	9	·325	2·200	1·892	10·033	48·085	152·38	151·39	·438
	14	·300	2·238	1·908	10·220	48·651	224·21	182·77	·455
	19	·276	2·275	1·924	10·346	49·155	296·11	214·21	·466
	24	·253	2·311	1·940	10·406	49·594	8·07	245·72	·471
	29	·233	2·345	1·955	10·397	49·965	80·11	277·31	·470
1886.									
Jan.	3	25·216	−2·377	−1·971	−10·317	50·264	152·21	308·96	+0·463
	8	·203	2·407	1·987	10·162	50·488	224·39	340·68	·449
	13	·194	2·435	2·002	9·930	50·634	296·64	12·47	·429
	18	·190	2·460	2·018	9·619	50·702	8·95	44·33	·403
	23	·191	2·482	2·033	9·229	50·691	81·33	76·26	·371
	28	·196	2·502	2·048	8·759	50·600	153·78	108·25	·334
Feb.	2	25·206	−2·518	−2·063	−8·211	50·430	226·28	140·30	+0·294
	7	·220	2·531	2·078	7·585	50·182	298·84	172·41	·251
	12	·238	2·541	2·093	6·885	49·862	11·44	204·56	·207
	17	·259	2·547	2·108	6·117	49·471	84·09	236·75	·163
	22	·281	2·548	2·123	5·285	49·018	156·77	268·98	·122
	27	·305	2·546	2·137	4·396	48·508	229·47	301·23	·084
Mar.	4	25·331	−2·540	−2·152	−3·459	47·951	302·18	333·49	+0·052
	9	·355	2·530	2·166	2·485	47·354	14·90	5·76	·027
	14	·377	2·516	2·180	1·484	46·729	87·61	38·01	·010
	19	·397	2·499	2·194	0·465	46·088	160·29	70·25	·001
	24	·415	2·479	2·208	+0·560	45·442	232·94	102·45	−0·001
	29	·429	2·456	2·222	1·579	44·799	305·55	134·60	·011
Apr.	3	25·440	−2·431	−2·236	+2·581	44·177	18·09	166·70	−0·029
	8	·448	2·404	2·250	3·554	43·581	90·58	198·74	·055
	13	·453	2·376	2·264	4·489	43·023	162·99	230·70	·088
	18	·456	2·347	2·278	5·377	42·514	235·31	262·5[illegible]	·126
	23	·457	2·318	2·291	6·210	42·059	307·56	294·3	·168
	28	·456	2·289	2·304	6·983	41·664	19·71	326·[illegible]	·213
May	3	25·455	−2·261	−2·318	+7·689	41·335	91·76	357·8	−0·258

of Jupiter 1885–86. By A. Marth.

Greenwich Noon.		Diameter Equat.	Diameter Polar.	Difference of limbs in A. R.	Difference of limbs in Decl.	Defect of illumination. Equat. preced. limb	Defect of illumination. in A. R.	Defect of illumination. in Decl. north *l*.	*d*	*ω*
1885.		″	″	s	″	″	s	″	°	°
Nov.	14	32·71	30·63	2·156	31·02	0·17	0·010	0·03	8·30	268·82
	19	33·07	30·97	2·179	31·36	·19	·011	·03	8·74	268·71
	24	33·46	31·33	2·205	31·73	·21	·012	·04	9·14	268·61
	29	33·87	31·72	2·233	32·12	·23	·013	·04	9·49	268·51
Dec.	4	34·31	32·13	2·262	32·54	0·25	0·014	0·04	9·79	268·41
	9	34·78	32·57	2·293	32·98	·27	·015	·05	10·03	268·32
	14	35·27	33·03	2·325	33·45	·28	·016	·05	10·22	268·23
	19	35·78	33·51	2·359	33·93	·29	·016	·05	10·35	268·13
	24	36·31	34·01	2·394	34·44	·30	·017	·05	10·41	268·03
	29	36·86	34·52	2·430	34·96	·30	·017	·05	10·40	267·92
1886. Jan.	3	37·43	35·05	2·468	35·49	0·30	0·017	0·05	10·32	267·81
	8	38·00	35·59	2·506	36·04	·30	·017	·05	10·16	267·68
	13	38·59	36·13	2 544	36·59	·29	·017	·05	9·93	267·54
	18	39·17	36·68	2·583	37·14	·28	·016	·04	9·62	267·39
	23	39·75	37·22	2·621	37·69	·26	·015	·04	9·23	267·22
	28	40·32	37·76	2·658	38·23	·24	·013	·04	8·76	267·03
Feb.	2	40·88	38·28	2·695	38·76	0·21	0·012	0·03	8·22	266·79
	7	41·41	38·78	2·730	39·27	·18	·010	·03	7·59	266·51
	12	41·91	39·24	2·763	39·74	·15	·009	·02	6·90	266·18
	17	42·37	39·67	2·793	40·18	·12	·007	·02	6·13	265·77
	22	42·78	40·06	2·820	40·57	·09	·005	·01	5·30	265·21
	27	43·14	40·39	2·843	40·91	·06	·004	·01	4·41	264·57
Mar.	4	43·43	40·67	2·863	41·19	0·04	0·002	0·00	3·48	263·24
	9	43·65	40·89	2·878	41·41	·02	·001		2·51	261·9
	14	43·82	41·04	2·888	41·56	·01	·000		1·53	256·4
	19	43 90	41·11	2·894	41·64	on following		on south	0·57	235·0
	24	43·91	41·12	2·895	41·65	limb		limb	0·63	117·3
	29	43·84	41·05	2·890	41·58	·01	·000	·00	1·60	99·0
Apr.	3	43·70	40 92	2·881	41·45	0 02	0·001	0·01	2·59	94·5
	8	43·48	40·72	2·867	41·24	·04	·002	·01	3·56	92·58
	13	43·20	40·46	2·849	40·98	·07	·004	·01	4·49	91·43
	18	42·86	40·14	2·827	40·65	·09	·005	·02	5·37	90·67
	23	42·47	39·77	2·801	40·28	·12	·007	·02	6·20	90·14
	28	42·03	39·36	2·772	39·86	·15	·009	·03	6·98	89·71
May	3	41·55	38·91	2·741	39·41	0·19	0·010	0 03	7·68	89·38

Greenwich Noon.	Angle of Position of ♃'s Axis.	Latitude of Earth above ♃'s Equator.	Sun	Annual Parallax.		Longitude of ♃'s Central Meridian. (870°·40)	(870°·31)	Corr. for Phase.
	P	B	*B*	A–L.	L–O.	I	II	
1886.	°	°	°	°	°	°		″
May 8	25·453	–2·234	–2·331	+8·324	41·077	163·72	29·19	–0·302
13	·452	2·209	2·344	8·886	40·893	235·59	60·61	·344
18	·451	2·186	2·357	9·372	40·784	307·36	91·94	·382
23	·450	2·165	2·370	9·783	40·751	19·04	123·17	·417
28	·450	2·146	2·383	10·119	40·793	90·63	154·31	·446
June 2	25·451	–2·130	–2·395	+10·381	40·909	162·13	185·37	–0·469
7	·451	2·117	2·408	10·569	41·098	233·56	216·35	·486
12	·452	2·106	2·420	10·686	41·359	304·91	247·25	·497
17	·453	2·098	2·433	10·734	41·688	16·18	278·08	·501
22	·453	2·093	2·445	10·717	42·082	87·39	308·85	·500
27	·452	2·091	2·457	10·638	42·539	158·54	339·55	·492
July 2	25·449	–2·091	–2·469	+10·499	43·056	229·64	10·20	–0·480
7	·444	2·094	2·481	10·303	43·629	300·68	40·80	·462
12	·436	2·099	2·493	10·053	44·256	11·68	71·35	·440
17	·423	2·107	2·505	9·754	44·932	82·64	101·86	·414
22	·406	2·117	2·517	9·408	45·656	153·56	132·34	·385
27	·384	2·129	2·528	9·018	46·423	224·46	162·79	·354
Aug. 1	25·358	–2·144	–2·539	+8·588	47·231	295·33	193·21	–0·321

The angle A–L is the difference of the Jovicentric longitudes of the Sun and the Earth, reckoned in the plane of *Jupiter's* equator, L–O+180° the Jovicentric longitude of the Earth reckoned from O, the point of *Jupiter's* vernal equinox or the point of the ascending node of the planet's orbit on its equator. Two values of the "Longitude of ♃'s Central Meridian" are given for each date, the first, computed with the daily rate of rotation 878°·40, being intended for comparing the observations of the white spots in the neighbourhood of the planet's equator; the second, computed with the rate 870°·31, for the observations of the remnant of the great reddish spot. As the variations of the motions of the white spot cannot yet be allowed for, on account of their apparent irregularities, I have adopted the daily rate 870°·40 as being the mean rate of rotation of the most persistent of the white spots from the autumn of 1880 to the spring of 1885, and have assumed the Zero Meridian so that it remains in the neighbourhood of that spot during the interval. I shall be ready to give the longitudes in the system of the present ephemeris, which correspond to the times of the observed passages of the white spots over the middle of the disc, when all, or nearly all, the observations have come to my knowledge. If the remnant of the great reddish spot should continue to rotate at the daily rate 870°·31, at which it has moved for more than two years,

Greenwich Noon.		Diameter Equat.	Diameter Polar.	Difference of limbs in A. R.	Difference of limbs in Decl.	Defect of illumination. Equat.	Defect of illumination. in A. R. preced. limb	Defect of illumination. in Decl. north l.	d	w
1886.		″	″	s	″	″	s	″	°	°
May	8	41·04	38·43	2·708	38·93	0·22	0·012	0·04	8·32	89·11
	13	40·50	37·93	2·673	38·42	·24	·014	·04	8·88	88·88
	18	39·95	37·41	2·636	37·89	·27	·015	·05	9·37	88·68
	23	39·39	36·88	2·599	37·36	·29	·016	·05	9·78	88·51
	28	38·82	36·35	2·562	36·82	·30	·017	·05	10·11	88·36
June	2	38·25	35·82	2·524	36·28	0·31	0·018	0·05	10·38	88·22
	7	37·69	35·29	2·487	35·75	·32	·018	·05	10·57	88·09
	12	37·14	34·77	2·450	35·22	·32	·018	·05	10·68	87·98
	17	36·59	34·27	2·414	34·71	·32	·018	·05	10·73	87·87
	22	36·07	33·77	2·379	34·21	·31	·018	·05	10·71	87·77
	27	35·56	33·30	2·345	33·73	·30	·017	·05	10·63	87·67
July	2	35·07	32·84	2·312	33·26	0·29	0·017	0·05	10·50	87·58
	7	34·60	32·40	2·281	32·82	·28	·016	·04	10·30	87·49
	12	34·15	31·98	2·252	32·39	·26	·015	·04	10·05	87·39
	17	33·73	31·58	2·224	31·99	·24	·014	·04	9·75	87·30
	22	33·33	31·21	2·197	31·61	·22	·013	·04	9·41	87·20
	27	32·95	30·86	2·172	31·25	·20	·012	·03	9·02	87·10
Aug.	1	32·60	30·53	2·149	30·92	0·18	0·011	0·03	8·59	87·00

its place will be found near the Zero Meridian of column II. of the values of the Longitude of ♃'s Central Meridian. The periods of rotation corresponding to the two adopted rates are

			h	m	s
I.	878°·40	period	9	50	9·84
II.	870·31		9	55	38·99

The differences of successive values of the "Longitude, &c.," amount for the intervals of five days to 12 rotations in addition to the differences directly deduced, which must be borne in mind in interpolating. The differences of the values for Nov. 14 and Nov. 19 are, for instance, 4391°·50 and 4351°·06. The addition of the "Correction for phase" to the "Longitude of ♃'s Central Meridian" gives the longitude of the Meridian which bisects the illuminated disc. A list of Greenwich times when this longitude is 0° will be found farther on.

The assumed value of *Jupiter's* equatorial diameter is $37''\cdot60$ at the distance 5·00273, or the apparent diameter $2a$ at the distance Δ

$$2a = \frac{195''\cdot62}{\Delta}.$$

The assumed proportion of the polar axis to the equatorial diameter or $\cos \epsilon_0$ is$=$0·9363. The formulæ for finding the

apparent polar diameter of the disc, the difference of the tangents to the limbs in A. R. and Declin., and the defects of illumination are (v. vol. xl. p. 490 ff):

$$\sin \epsilon = \sin \epsilon_0 \cos B \qquad \tan B_{,} = \sec \epsilon_0 \tan B$$
$$\sin \nu_{,} = \sin \epsilon \sin P \qquad \tan B' = \sec \epsilon_{,} \tan B \sec (A - L)$$
$$\sin \nu' = \sin \epsilon \cos P \qquad \tan d \sin w = \tan (A - L) \cos B' \sec (B_{,} - B')$$
$$\tan P_{,} = \cos \epsilon \tan P \qquad \tan d \cos w = \tan (B_{,} - B')$$
$$\tan P' = \sec \epsilon \tan P$$

$$\sin \delta = \sin d \sin w \qquad \sin \delta'' = \sin d \cos w$$
$$\sin \delta_{,} = \sin d \sin (w + P_{,}) \qquad \sin \delta' = \sin d \cos (w + P')$$

$$\text{App. equat. diameter} = 2a \qquad \text{Defect of illum.} = 2a \,.\, \sin^2 \tfrac{1}{2}\delta$$
$$\text{App. polar diameter} = 2a \cos \epsilon \qquad = 2a \cos \epsilon \,.\, \sin^2 \tfrac{1}{2}\delta'' \text{ (insensible)}$$
$$\text{Diff. of limbs in A.R.} = \frac{2a \cos \nu_{,}}{15 \cos D} \qquad = \frac{2a \cos \nu_{,}}{15 \cos D} \,.\, \sin^2 \tfrac{1}{2}\delta_{,}$$
$$\text{,, in Decl.} = 2a \cos \nu' \qquad = 2a \cos \nu' \,.\, \sin^2 \tfrac{1}{2}\delta'$$

The values of δ, &c., are, of course, not wanted, and, with the help of a little table giving

$$\log \frac{1}{4 \cos^4 \frac{1}{2}\delta}$$

belonging to the argument $\log \sin^2 \delta$, the values of $\sin^2 \frac{1}{2}\delta$ are found by the formula

$$\frac{\sin^2 \delta}{4 \cos^2 \frac{1}{2}\delta}.$$

The inclinations γ and the ascending nodes Γ of the orbits of the four satellites of *Jupiter* in reference to the plane of the planet's equator are the following, the longitudes of the nodes being reckoned from O, the point of the ascending node of *Jupiter's* orbit on its equator :—

1885.	γ_1	Γ_1	γ_2	Γ_2	γ_3	Γ_3	γ_4	Γ_4
Sept. 15	0°·0116	305°·2	0°·4895	307°·29	0°·1545	252°·54	0°·3187	329°·91
Nov. 14	·0116	303·7	·4900	305·39	·1536	252·31	·3191	329·93
1886.								
Jan. 13	0·0117	302·3	0·4905	303·49	0·1527	252·09	0·3195	329·97
Mar. 14	·0118	300·9	·4910	301·60	·1518	251·87	·3198	330·03
May 13	·0118	299·5	·4914	299·21	·1508	251·64	·3201	330·10
July 12	·0118	298·2	·4918	297·83	·1498	251·41	·3203	330·19
Sept. 10	0·0118	296·9	0·4921	295·94	0·1487	251·17	0·3205	330·29

The values for the preceding two years are given in the "Note on the Determination of the Planes of the Orbits of *Jupiter's* Satellites," published in vol. xliv. p. 241 ff. At the

end of that note it is pointed out that observers ought to be on the alert in 1886 to get complete observations of some of the last eclipses of the present cycle of eclipses of the fourth satellite. If, as is very probable, the tabular value of the node of that satellite's orbit on the orbit of *Jupiter* requires a very sensible positive correction, the durations of the last eclipses as given by the Tables will not only be found considerably too short, but there will be at least one additional eclipse on May 17 not given by the Tables, and there may be a second unpredicted one of short duration on June 3. It is not unlikely that the errors of the predicted times of the eclipse on March 11 may already amount to a quarter of an hour, the satellite disappearing so much earlier and reappearing so much later than the times set down in the *Nautical Almanac*, and these errors will then be considerably increased in the following eclipses, so that observers will have to look out early enough for the disappearance and watch long enough for the reappearance of the satellite. It is to be hoped that the opportunities for securing valuable observations will not be allowed to slip away unused by observers in Europe on March 11 and May 17 (middle of eclipse of uncertain duration at $11^h\ 26^m{\cdot}8$ G.M.T.), in Asia on March 28 and June 3 (middle of possible eclipse at $5^h\ 25^m{\cdot}1$ G.M.T.), in Australia on April 13 and in America on April 30. It is obvious that the times of corresponding phases at disappearance and reappearance must be observed, if good results are to be deduced.

The following is a list of Greenwich Mean Times, when the Zero Meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc. To save printing, the time of only one passage is given for each day, and the others must be found by interpolation, or, if greater accuracy is not required, by adding or subtracting $9^h\ 50^m$ in the first system and $9^h\ 56^m$ in the second.

	I.	II.		I.	II.
	(878°·40)	(870°·31)		(878°·40)	(870°·31)
1885	h m	h m	1885	h m	h m
Nov. 9	17 24·4	20 49·8	Nov. 20	19 0·5	14 58·4
10	22 55·1	16 41·2	21	14 40·9	20 45·5
11	18 35·5	22 28·8	22	20 11·6	16 36·0
12	14 16·0	18 19·4	23	15 52·0	22 24·9
13	19 46·7	14 11·3	24	21 22·6	18 15·4
14	15 27·1	19 58·4	25	17 3·1	14 6·8
15	20 57·8	15 49·8	26	12 43·5	19 53·9
16	16 38·3	21 37·0	27	18 14·1	15 45·3
17	22 8·9	17 28·4	28	13 54·5	21 32·3
18	17 49·4	13 19·8	29	19 25·1	17 23·7
19	13 29·8	19 6·9	30	15 5·5	13 15·1

		I. (878°·40)	II. (870°·31)			I. (878°·40)	II. (870°·31)
1885		h m	h m	1886.		h m	h m
Dec.	1	20 36·1	19 2·2	Jan.	6	12 21·0	18 44·3
	2	16 16·5	14 53·5		7	17 51·4	14 35·6
	3	21 47·1	20 40·6		8	13 31·7	10 26·8
	4	17 27·5	16 32·0		9	19 2·1	16 13·7
	5	13 7·9	12 23·3		10	14 42·4	12 4·9
	6	18 38·5	18 10·4		11	10 22·6	17 51·8
	7	14 18·9	14 1·7		12	15 53·0	13 43·0
	8	19 49·5	19 48·8		13	11 33·3	19 29·9
	9	15 29·9	15 40·1		14	17 3·7	15 21·1
	10	21 0·4	21 27·1		15	12 43·9	11 12·3
	11	16 40·8	17 18·5		16	18 14·3	16 59·2
	12	12 21·1	13 9·8		17	13 54·5	12 50·4
	13	17 51·7	18 56·8		18	19 24·9	18 37·2
	14	13 32·0	14 48·2		19	15 5·1	14 28·4
	15	19 2·6	20 35·2		20	10 45·4	10 19·6
	16	14 42·9	16 26·5		21	16 15·7	16 6·4
	17	20 13·5	12 17·8		22	11 56·0	11 57·6
	18	15 53·8	18 4·8		23	17 26·3	17 44·4
	19	11 34·1	13 56·1		24	13 6·5	13 35·6
	20	17 4·7	19 43·1		25	8 46·7	9 26·8
	21	12 45·0	15 34·4		26	14 17·1	15 13·6
	22	18 15·5	11 25·7		27	9 57·3	11 4·8
	23	13 55·8	17 12·6		28	15 27·6	16 51·5
	24	19 26·3	13 3·9		29	11 7·8	12 42·7
	25	15 6·6	18 50·9		30	16 38·1	18 29·5
	26	20 37·1	14 42·2		31	12 18·3	14 20·6
	27	16 17·4	20 29·1	Feb.	1	17 48·6	10 11·8
	28	11 57·8	16 20·4		2	13 28·8	15 58·6
	29	17 28·2	12 11·7		3	9 9·0	11 49·7
	30	13 8·5	17 58·6		4	14 39·3	17 36·5
	31	18 39·0	13 49·9		5	10 19·5	13 27·6
1886.					6	15 49·7	9 18·8
Jan.	1	14 19·3	19 36·8		7	11 29·9	15 5·5
	2	19 49·7	15 28·0		8	17 0·2	10 56·7
	3	15 30·0	11 19·3		9	12 40·4	16 43·4
	4	11 10·3	17 6·2		10	8 20·6	12 34·5
	5	16 40·7	12 57·5		11	13 50·8	8 25·7

1886	I. (878°·40) h m	II. (870°·31) h m	1886	I. (878°·40) h m	II. (870°·31) h m
Feb. 12	9 31·0	14 12·4	Mar. 21	6 37·7	9 37·1
13	15 1·2	10 3·5	22	12 7·9	15 23·8
14	10 41·4	15 50·2	23	7 48·1	11 15·0
15	16 11·7	11 41·4	24	13 18·3	7 6·1
16	11 51·8	17 28·1	25	8 58·5	12 52·8
17	17 22·1	13 19·2	26	14 28·8	8 43·9
18	13 2·2	9 10·3	27	10 8·9	14 30·6
19	8 42·4	14 57·0	28	15 39·2	10 21·8
20	14 12·6	10 48·1	29	11 19·4	6 12·9
21	9 52·8	16 34·8	30	6 59·5	11 59·6
22	15 23·0	12 25·9	31	12 29·8	7 50·8
23	11 3·1	8 17·1	Apr. 1	8 10·0	13 37·5
24	16 33·4	14 3·7	2	13 40·3	9 28·7
25	12 13·5	9 54·8	3	9 20·5	15 15·4
26	17 43·7	15 41·5	4	14 50·8	11 6·6
27	13 23·9	11 32·6	5	10 31·0	6 57·8
28	9 4·0	7 23·8	6	6 11·2	12 44·5
Mar. 1	14 34·2	13 10·4	7	11 41·5	8 35·7
2	10 14·4	9 1·5	8	7 21·7	14 22·5
3	15 44·6	14 48·2	9	12 52·0	10 13·7
4	11 24·7	10 39·3	10	8 32·3	6 4·9
5	16 55·0	16 26·0	11	14 2·6	11 51·7
6	12 35·1	12 17·1	12	9 42·9	7 42·9
7	8 15·2	8 8·2	13	15 13·2	13 30·7
8	13 45·5	13 54·9	14	10 53·4	9 20·9
9	9 25·6	9 46·0	15	6 33·7	15 7·7
10	14 55·8	15 32·6	16	12 4·1	10 58·9
11	10 36·0	11 23·8	17	7 44·3	6 50·2
12	6 16·1	7 14·9	18	13 14·7	12 37·0
13	11 46·3	13 1·5	19	8 55·0	8 28·2
14	7 26·5	8 52·6	20	14 25·4	14 15·1
15	12 56·7	14 39·3	21	10 5·7	10 6·4
16	8 36·8	10 30·4	22	15 36·1	15 53·2
17	14 7·0	16 17·1	23	11 16·4	11 44·5
18	9 47·2	12 8·2	24	6 56·8	7 35·8
19	15 17·4	7 59·3	25	12 27·1	13 22·7
20	10 57·6	13 46·0	26	8 7·4	9 13·

		I. (878°·40)	II. (870°·31)
1886		h m	h m
Apr.	27	13 37·9	15 0·8
	28	9 18·2	10 52·1
	29	14 48·7	16 39·1
	30	10 29·0	12 30·4
	—	17 28·4	Middle of last tabular eclipse of Sat. IV.
May	1	15 59·5	8 21·6
	2	11 39·8	14 8·6
	3	7 20·2	9 59·9
	4	12 50·7	15 46·9
	5	8 31·0	11 38·2
	6	14 1·5	7 29·5
	7	9 41·9	13 16·5
	8	15 12·4	9 7·9
	9	10 52·8	14 54·9
	10	16 23·4	10 46·2
	11	12 3·8	16 33·2
	12	7 44·1	12 24·6
	13	13 14·7	8 16·0
	14	8 55·1	14 3·0
	15	14 25·7	9 54·4
	16	10 6·1	15 41·4
	17	11 26·8	? Middle of eclipse of Sat. IV.
	—	15 36·7	11 32·8
	18	11 17·1	7 24·2
	19	6 57·5	13 11·3
	20	12 28·2	9 2·7
	21	8 8·6	14 49·8
	22	13 39·2	10 41·2
	23	9 19·7	16 28·3
	24	14 50·3	12 19·7
	25	10 30·8	8 11·1
	26	16 1·5	13 58·2
	27	11 42·9	9 49·7
	28	7 22·4	15 36·8

		I. (878°·40)	II. (870°·31)
		h m	h m
May	29	12 53·1	11 28·2
	30	8 33·5	7 19·7
	31	14 4·2	13 6·8
June	1	9 44·7	8 58·3
	2	15 15·4	14 45·5
	3	5 25·1	? Middle of eclipse of Sat. IV.
	—	10 55·9	10 36·9
	4	6 36·4	6 28·4
	5	12 7·1	12 15·6
	6	7 47·6	8 7·0
	7	13 18·4	13 54·3
	8	8 58·9	9 45·7
	9	14 29·6	15 32·9
	10	10 10·1	11 24·4
	11	15 40·9	7 15·9
	12	11 21·4	13 3·1
	13	7 1·9	8 54·6
	14	12 32·7	14 41·9
	15	8 13·2	10 33·4
	16	13 44·0	6 24·9
	17	9 24·6	12 12·1
	18	14 55·4	8 3·7
	19	10 35·9	13 50·9
	20	6 16·4	9 42·4
	21	11 47·2	5 34·0
	22	7 27·8	11 21·2
	23	12 58·6	7 12·8
	24	8 39·2	13 0·1
	25	14 10·0	8 51·6
	26	9 50·6	14 38·9
	27	5 31·1	10 30·4
	28	11 2·0	6 22·0
	29	6 42·5	12 9·3
	30	12 13·4	8 0·8
July	1	7 54·0	13 48·1
	2	13 24·8	9 39·7

1885	I. (878°·40) h m	II. (870°·31) h m	1886	I. (878°·40) h m	II. (870°·31) h m
July 3	9 5·4	15 27·0	July 20	14 17·9	14 34·2
4	14 36·3	11 18·6	21	9 58·5	10 25·8
5	10 16·9	7 10·1	22	5 39·1	6 17·4
6	5 57·4	12 57·5	23	11 10·0	12 4·8
7	11 28·3	8 49·0	24	6 50·7	7 56·4
8	7 8·9	14 36·4	25	12 21·6	13 43·8
9	12 39·8	10 27·9	26	8 2·2	9 35·4
10	8 20·4	6 19·5	27	13 33·1	5 27·0
11	13 51·3	12 6·9	28	9 13·8	11 14·4
12	9 31·9	7 58·4	29	14 44·7	7 6·0
13	5 12·5	13 45·8	30	10 25·3	12 53·4
14	10 43·4	9 37·4	31	6 5·9	8 45·0
15	6 24·0	5 28·9	Aug. 1	11 36·9	14 32·4
16	11 54·9	11 16·3	2	7 17·5	10 24·0
17	7 35·5	7 7·9	3	12 48·5	6 15·6
18	13 6·4	12 55·3	4	8 29·1	12 3·0
19	8 47·0	8 46·9			

Ephemerides of the Satellites of Saturn, 1885–86. By A. Marth.

(*Continued from page 462.*)

Differences of Right Ascension and Declination between the three outer Satellites and the Centre of Saturn.

0h Gr. 1885.	*Titan.* $\alpha_6 - A$ s	$\delta_6 - D$ ″	*Hyperion.* $\alpha_7 - A$ s	$\delta_7 - D$ ″	*Iapetus.* $\alpha_8 - A$ s	$\delta_8 - D$ ″
Dec. 1	− 4·79	− 92·3	+ 6·65	+ 102·8	+ 24·83	− 49·4
2	+ 0·83	− 89·8	+ 1·05	+ 100·1	+ 27·61	− 37·0
3	+ 6·34	− 74·5	− 4·67	+ 86·3	30·22	− 24·3
4	+ 10·95	− 48·5	− 9·83	+ 62·1	+ 32·65	− 11·4
5	+ 13·96	− 15·3	− 13·76	+ 30·2	34·88	+ 1·6
6	+ 14·87	+ 20·2	− 15·96	− 5·7	+ 36·91	+ 14·6
7	+ 13·47	+ 52·6	− 16·22	− 41·1	38·72	27·6
8	+ 9·90	+ 76·6	− 14·63	− 71·9	+ 40·30	+ 40·6
9	+ 4·70	+ 88·0	− 11·51	− 95·5	41·65	53·4
10	− 1·30	+ 84·7	− 7·36	− 110·3	+ 42·74	+ 65·8
11	− 7·09	+ 67·1	− 2·56	− 115·9	43·57	77·9
12	− 11·71	+ 38·3	+ 2·45	− 112·8	+ 44·14	+ 89·7

0^h Gr.		*Titan.*		*Hyperion.*		*Iapetus.*	
		α_6-A	δ_6-D	α_7-A	α_7-D	α_8-A	δ_8-D
1885.		s	″	s	″	s	″
Dec.	13	−14·44	+ 3·2	+ 7·30	− 101·7	+44·45	+100·9
	14	−14·89	− 32·5	+11·67	− 83·9	+44·50	+111·6
	15	−13·07	− 63·3	+15·30	− 60·7	44·27	121·6
	16	− 9·31	− 84·9	+17·98	− 33·7	+43·77	+131·0
	17	− 4·20	− 94·3	+19·52	− 4·5	43·01	139·6
	18	+ 1·51	− 90·2	+19·80	+ 25·1	+41·99	+147·3
	19	+ 7·01	− 73·4	+18·72	+ 52·9	40·71	154·2
	20	+11·50	− 46·0	+16·28	+ 76·9	+39·18	+160·2
	21	+14·31	− 11·8	+12·54	+ 94·8	37·41	165·2
	22	+14·96	+ 24·2	+ 7·69	+ 104·3	+35·41	+169·2
	23	+13·27	+ 56·3	+ 2·10	+ 103·6	33·19	172·2
	24	+ 9·45	+ 79·5	− 3·71	+ 91·6	+30·75	+174·2
	25	+ 4·07	+ 89·5	− 9·07	+ 68·9	28·12	175·0
	26	− 2·00	+ 84·5	−13·30	+ 37·5	+25·32	+174·7
	27	− 7·73	+ 65·3	−15·84	+ 1·3	22·36	173·3
	28	−12·18	+ 35·2	−16·42	− 35·1	+19·26	+170·8
	29	−14·65	− 0·6	−15·11	− 67·5	16·03	167·2
	30	−14·82	− 36·4	−12·21	− 92·9	+12·70	+162·5
	31	−12·73	− 66·7	− 8·14	− 109·6	9·29	156·7
1836. Jan.	1	− 8·77	− 87·2	− 3·38	− 117·0	+ 5·82	+149·9
	2	− 3·53	− 95·2	+ 1·66	− 115·3	+ 2·31	142·1
	3	+ 2·20	− 89·6	+ 6·57	− 105·4	− 1·21	+133·3
	4	+ 7·62	− 71·3	+11·05	− 88·5	4·72	123·6
	5	+11·94	− 42·8	+14·81	− 65·9	− 8·20	+113·1
	6	+14·50	− 8·0	+17·65	− 39·1	11·61	101·8
	7	+14·86	+ 27·9	+19·37	− 9·9	−14·94	+ 89·7
	8	+12·91	+ 59·5	+19·84	+ 19·9	18·16	77·0
	9	+ 8·88	+ 81·4	+18·99	+ 48·4	−21·26	+ 63·8
	10	+ 3·39	+ 89·9	+16·75	+ 73·3	24·21	50·1
	11	− 2·66	+ 83·3	+13·22	+ 92·5	−26·98	+ 36·1
	12	− 8·26	+ 62·7	+ 8·56	+ 103·7	29·56	21·8
	13	−12·49	+ 31·7	+ 3·10	+ 104·9	−31·92	+ 7·3
	14	−14·69	− 4·4	− 2·68	+ 95·0	34·06	− 7·3
	15	−14·58	− 39·8	− 8·12	+ 74·2	−35·95	− 21·8
	16	−12·26	− 69·2	−12·55	+ 44·1	37·59	36·2
	17	− 8·14	− 88·5	−15·38	+ 8·6	−38·96	− 50·3
	18	− 2·85	− 94·9	−16·29	− 28·1	40·05	64·1
	19	+ 2·83	− 88·0	−15·30	− 61·5	−40·85	− 77·4

0ʰ Gr. 1886.		Titan. α_6-A	Titan. δ_6-D	Hyperion. α_7-A	Hyperion. δ_7-D	Iapetus. α_8-A	Iapetus. δ_8-D
		s	″	s	″	s	″
Jan.	20	+ 8·10	− 68·5	− 12·66	− 88·3	− 41·36	− 90·2
	21	+ 12·20	− 39·3	− 8·80	− 106·5	− 41·57	− 102·4
	22	+ 14·50	− 4·3	− 4·18	− 115·6	41·49	113·8
	23	+ 14·60	+ 31·2	+ 0·77	− 115·5	− 41·12	− 124·4
	24	+ 12·42	+ 61·7	+ 5·66	− 107·2	40·46	134·2
	25	+ 8·25	+ 82·3	+ 10·16	− 91·6	− 39·52	− 143·0
	26	+ 2·73	+ 89·2	+ 14·00	− 70·1	38·30	150·8
	27	− 3·24	+ 81·2	+ 16·95	− 44·2	− 36·81	− 157·5
	28	− 8·65	+ 59·6	+ 18·83	− 15·7	35·07	163·2
	29	− 12·60	+ 28·2	+ 19·51	+ 13·8	− 33·10	− 167·7
	30	− 14·55	− 7·8	+ 18·89	+ 42·3	30·91	171·0
	31	− 14·20	− 42·4	+ 16·95	+ 67·7	− 28·51	− 173·2
Feb.	1	− 11·71	− 70·7	+ 13·72	+ 87·9	25·92	174·2
	2	− 7·51	− 88·5	+ 9·34	+ 100·7	− 23·16	− 174·0
	3	− 2·23	− 93·6	+ 4·12	+ 104·0	20·26	172·7
	4	+ 3·34	− 85·5	− 1·51	+ 96·5	− 17·24	− 170·2
	5	+ 8·43	− 65·3	− 6·93	+ 78·1	14·11	166·6
	6	+ 12·29	− 35·8	− 11·50	+ 50·3	− 10·89	− 161·9
	7	+ 14·33	− 1·1	− 14·60	+ 16·2	7·62	156·1
	8	+ 14·21	+ 33·6	− 15·86	− 19·9	− 4·31	− 149·4
	9	+ 11·88	+ 62·9	− 15·21	− 53·6	− 0·98	141·7
	10	+ 7·64	+ 82·1	− 12·98	− 81·4	+ 2·35	− 133·2
	11	+ 2·16	+ 87·6	− 9·43	− 101·2	5·65	123·8
	12	− 3·67	+ 78·5	− 5·05	− 112·0	+ 8·90	− 113·6
	13	− 8·86	+ 56·3	− 0·27	− 113·8	12·08	102·8
	14	− 12·58	+ 24·9	+ 4·51	− 107·3	+ 15·18	− 91·4
	15	− 14·27	− 10·4	+ 8·97	− 93·5	18·18	79·4
	16	− 13·74	− 44·1	+ 12·84	− 73·8	+ 21·05	− 67·0
	17	− 11·15	− 71·0	+ 15·90	− 49·4	23·78	54·2
	18	− 6·93	− 87·6	+ 17·96	− 22·1	+ 26·36	− 41·1
	19	− 1·73	− 91·6	+ 18·88	+ 6·5	28·78	27·8
	20	+ 3·69	− 82·6	+ 18·56	+ 34·6	+ 31·02	− 14·4
	21	+ 8·57	− 62·0	+ 16·96	+ 60·2	33·06	− 1·0
	22	+ 12·21	− 32·7	+ 14·11	+ 81·2	+ 34·90	+ 12·5
	23	+ 14·05	+ 1·4	+ 10·11	+ 95·5	36·53	25·9
	24	+ 13·76	+ 35·0	+ 5·22	+ 101·1	+ 37·95	+ 39·0
	25	+ 11·32	+ 63·1	− 0·17	+ 96·4	39·14	51·8
	26	+ 7·10	+ 80·9	− 5·51	+ 81·0	+ 40·09	+ 64·3

0h Gr. 1886		Titan. α_6-A s	δ_6-D ″	Hyperion. α_7-A s	δ_7-D ″	Iapetus. α_8-A s	δ_8-D ″
Feb.	27	+ 1·71	+ 85·4	−10·17	+ 56·1	+40·81	+ 76·4
	28	− 3·94	+ 75·6	−13·54	+ 24·1	+41·29	+ 88·0
Mar.	1	− 8·92	+ 53·2	−15·20	− 10·7	41·53	99·1
	2	−12·42	+ 22·2	−15·05	− 44·2	+41·52	+109·5
	3	−13·92	− 12·3	−13·22	− 72·7	41·28	119·3
	4	−13·27	− 44·8	−10·08	− 93·9	+40·80	+128·3
	5	−10·63	− 70·5	− 6·03	−106·5	40·09	136·5
	6	− 6·45	− 85·9	− 1·51	−110·5	+39·16	+144·0
	7	− 1·37	− 89·0	+ 3·11	−106·3	38·08	150·6
	8	+ 3·88	− 79·6	+ 7·51	− 95·0	+36·62	+156·3
	9	+ 8·56	− 59·0	+11·40	− 77·3	35·03	161·0
	10	+12·01	− 30·1	+14·57	− 54·9	+33·25	+164·8
	11	+13·69	+ 3·1	+16·82	− 29·2	31·28	167·6
	12	+13·30	+ 35·6	+18·02	− 1·8	+29·14	+169·4
	13	+10·85	+ 62·5	+18·06	+ 25·6	26·84	170·2
	14	+ 6·66	+ 79·2	+16·87	+ 51·1	+24·38	+170·0
	15	+ 1·40	+ 82·9	+14·46	+ 72·8	21·79	168·7
	16	− 4·07	+ 72·7	+10·91	+ 88·6	+19·07	+166·5
	17	− 8·85	+ 50·5	+ 6·41	+ 96·5	16·26	163·2
	18	−12·17	+ 20·2	+ 1·32	+ 94·9	+13·36	+159·0
	19	−13·54	− 13·3	− 3·90	+ 83·0	10·39	153·9
	20	−12·82	− 44·7	− 8·63	+ 61·4	+ 7·36	+147·8
	21	−10·19	− 69·2	−12·27	+ 32·3	4·31	140·8
	22	− 6·10	− 83·7	−14·36	− 0·8	+ 1·24	+133·0
	23	− 1·16	− 86·3	−14·72	− 33·6	− 1·84	124·4
	24	+ 3·93	− 76·7	−13·43	− 62·7	− 4·88	+115·1
	25	+ 8·45	− 56·4	−10·76	− 85·2	7·87	105·1
	26	+11·74	− 28·2	− 7·12	− 99·9	−10·81	+ 94·4
	27	+13·31	+ 4·0	− 2·91	−106·5	13·67	83·2
	28	+12·87	+ 35·5	+ 1·52	−104·6	−16·43	+ 71·6
	29	+10·44	+ 61·3	+ 5·83	− 95·8	19·07	59·6
	30	+ 6·34	+ 77·2	+ 9·75	− 80·8	−21·57	+ 47·2
	31	+ 1·22	+ 80·3	+13·03	− 60·6	23·93	34·5
April	1	− 4·08	+ 70·1	+15·50	− 36·9	−26·12	+ 21·7
	2	− 8·69	+ 48·3	+17·01	− 11·0	28·14	+ 8·8
	3	−11·87	+ 18·7	+17·44	+ 15·5	−29·96	− 4·0
	4	−13·15	− 13·7	+16·70	+ 40·8	31·57	16·7
	5	−12·43	− 44·0	+14·77	+ 63·3	−32·97	− 29·3

o^h Gr. 1886.	*Titan.* α_6-A s	δ_6-D "	*Hyperion.* α_7-A s	δ_7-D "	*Iapetus.* α_8-A s	δ_8-D "
Apr. 6	− 9·85	− 67·6	+ 11·72	+ 80·5	− 34·15	− 41·6
7	− 5·87	− 81·4	+ 7·66	+ 90·8	− 35·10	− 53·6
8	− 1·07	− 83·6	+ 2·98	+ 92·4	35·81	65·1
9	+ 3·87	− 74·2	− 2·07	+ 84·2	− 36·28	− 76·2
10	+ 8·25	− 54·4	− 6·86	+ 66·3	36·51	86·7
11	+ 11·43	− 26·9	− 10·78	+ 40·4	− 36·49	− 96·5
12	+ 12·94	+ 4·4	− 13·35	+ 9·5	36·24	105·7
13	+ 12·50	+ 34·9	− 14·29	− 22·5	− 35·75	− 114·1
14	+ 10·12	+ 59·8	− 13·58	− 51·8	35·02	121·7
15	+ 6·13	+ 75·0	− 11·46	− 75·6	− 34·07	− 128·5
16	+ 1·15	+ 77·9	− 8·27	− 92·3	32·90	134·4
17	− 4·00	+ 67·8	− 4·39	− 101·2	− 31·52	− 139·3
18	− 8·48	+ 46·6	− 0·19	− 102·4	29·94	143·4
19	− 11·56	+ 17·9	+ 4·01	− 96·3	− 28·18	− 146·5
20	− 12·82	− 13·6	+ 7·94	− 84·0	26·24	148·6
21	− 12·11	− 42·9	+ 11·35	− 66·4	− 24·14	− 149·8
22	− 9·62	− 65·7	+ 14·06	− 44·8	21·90	150·1
23	− 5·75	− 79·1	+ 15·90	− 20·6	− 19·53	− 149·4
24	− 1·08	− 81·2			17·04	147·7
25	+ 3·73	− 72·0			− 14·46	− 145·2
26	+ 7·99	− 52·8			11·80	141·8
27	+ 11·11	− 26·1			− 9·07	− 137·5
28	+ 12·60	+ 4·3			6·30	132·5
29	+ 12·19	+ 33·9			− 3·50	− 126·7
30	+ 9·89	+ 58·1			− 0·69	120·2
May 1	+ 6·02	+ 72·9			+ 2·12	− 112·9
2	+ 1·17	+ 75·5			4·91	105·0
3	− 3·85	+ 65·9			+ 7·66	− 96·7

Note on Stationary Radiant Points. By Richard A. Proctor.

It is hardly necessary for me to point out that the results indicated by Mr. Denning, in the June number of the *Notices*, with regard to meteoric velocities, and his supposed recognition of stationary radiants, are not congruous. A radiant really stationary for three or four months, or varying only by a degree or so in that time, implies *of necessity* a velocity of meteoric motion many times greater than the velocity of the earth in her orbit.

Unless Mr. Denning has been deceived by accidental coincidence of the radiants of really different streams (which is not unlikely in some of his instances), we must assume that either his observations do not determine radiants so closely as he has supposed, or else the velocities deduced from multiple observations for meteors of these streams cannot be trusted. More probably both sources of error exist.

If (1) we reject as mere chance coincidences all stationary radiants lasting more than two months or so; (2) assume that none of these radiants have been determined within less than three or four degrees; and (3) suppose that in the case of streams having radiants thus far stationary, there are velocities ranging up to about 150 miles per second, incongruity disappears, and Mr. Denning's observations are treated with the least possible violence.

My own theory antedates Mr. Denning's observations by ten or twelve years, and is in no sense affected by our way of viewing them.

INDEX.

LIST OF PRESENTS

RECEIVED DURING THE SESSION OF 1884-85,

AND OF

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DURING THE SAME PERIOD,

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